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Aviation Weather System Plan

October 1985

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**Federal Aviation
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Office of the Administrator

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Washington, D.C. 20591

This second edition of the Aviation Weather System Plan highlights the needs and requirements expressed by the users of the National Airspace System. Through comprehensive coordination and review, airspace user requirements have been defined and balanced against a weather program designed to meet their needs. The plan provides a general overview of Federal weather activities. It documents what the Federal Aviation Administration and other Federal agencies are doing, and the direction that aviation weather system developments are taking.

This plan is our method of ensuring that all segments of the aviation community are aware of ongoing programs and planned actions and have an opportunity to comment on these Federal weather plans and programs. I am pleased to note that very few negative comments were received this year. I hope this means that we are addressing the right problems in the right way. Future editions of the plan will contain even greater amounts of detail concerning the emerging system, the kind of information all users will need to know in order to plan their individual interaction with the Aviation Weather System.

Donald D. Engen

Donald D. Engen
Administrator

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1. INTRODUCTION

The provision of aviation weather information in the United States is a joint venture directly involving the Federal Aviation Administration (FAA), the National Oceanic and Atmospheric Administration (NOAA), the Department of Defense (DoD), and the civil aviation community. In addition, there are other Federal agencies such as the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) sponsoring research aimed at improving the knowledge of the atmosphere, as well as improving the ability to detect and forecast atmospheric changes. The joint aspects of aviation weather are highlighted in the Federal Aviation Act of 1958. In this act, the Congress directed the National Weather Service (NWS) to provide reports, forecasts, and warnings to the Federal Aviation Administration for use in aviation, and directed the FAA to develop, procure, operate, and maintain equipment for disseminating aviation weather information.

The current Aviation Weather System is limited in its ability to rapidly acquire measured or observed data, and to process and disseminate operationally significant information to various categories of users. Capabilities to detect real-time weather situations that could adversely affect operational safety are also limited. The significant improvements which are required will be more readily achieved if the efforts of everyone involved are directed in an organized manner. The FAA has assumed a leadership role in this concerted effort to define the activities needed to improve the accuracy, availability, and timeliness of aviation weather information. The FAA Deputy Associate Administrator for Engineering is the aviation weather focal point, charged with ensuring that the agency has a comprehensive, integrated, and coordinated aviation weather program. He is directly assisted in the execution of this charge by the Weather Coordination Program staff.

Since the provision of aviation weather information is a joint venture, whatever the agency does internally cannot be done without external coordination. The Aviation Weather System Plan is the living document through which external coordination is accomplished and it serves as the basis for concerted action by all involved parties. The Plan contains the Aviation Weather System requirements as well as the programs designed to meet them.

The program portion in the first edition of the Plan dealt primarily with those elements which are under the FAA's control and/or are defined in the National Airspace System Plan. In this second edition of the Plan, other agencies' weather-related programs and joint programs have also been included. The primary purpose of the Aviation Weather System Plan is to provide the aviation community with a general overview of the current Aviation Weather System and of the programs, planned and on-going, that will improve aviation weather services. The Plan is a single source document that highlights the activities of the various Federal and State entities involved in aviation weather. In developing the Plan, user requirements, recommendations, comments, and review were solicited and included to the extent practicable.

This Plan is designed to supplement other FAA plans and program documentation and does not supplant them. The Plan reflects general schedules, major milestones and accomplishments of current programs, but does not present extensive details on individual programs and projects. It is not the purpose of this document to present specific information pertaining to costs and technical specifications. For the concerned reader, this information is available in other FAA documentation or reflected in the plans of other agencies with primary program responsibility.

As the Aviation Weather System evolves, this Plan will be refined to reflect the products and services available to users. Future editions of the Plan will describe what is available in the system and where and how the user can access these products and services. This will provide a basis for the users to evaluate the impact of system changes on their particular operation, and assist in decisions on resource expenditures, procedural changes and equipment modifications required to take full advantage of the changing system.

The FAA's Systems Engineering Service will ensure that the FAA programs described in this Plan are integrated into a comprehensive system. As the systems integration effort increases, there will be changes particularly in the various interfaces. The Aviation Weather System Plan is to be used as a vehicle to communicate these changes to the user community.

2. CURRENT AVIATION WEATHER SYSTEM

SYSTEM OVERVIEW

The existing Aviation Weather System is a collection of functionally independent elements, each of which was developed and implemented as a solution to a specific operational problem. During the past 10 to 15 years, with the advent of high speed communications and automated data processing, a number of system improvements have been implemented. Further improvements are needed, however, to enhance the system productivity and to meet the demand for timely and accurate weather information and services.

The overall logical links between the NWS, FAA, and airspace users are depicted in Figure 2-1. In the present system, NWS acquires meteorological data from various acquisition systems, processes the data, and generates alphanumeric and graphic weather products. It then distributes them to the FAA and other users. FAA, DoD, and Coast Guard also collect some raw meteorological data required for producing various weather products. However, the FAA's primary responsibility in the current Aviation Weather System is the dissemination of relevant and vital weather information to airspace users.

Figure 2-2 shows the flow of information in the current Aviation Weather System. This system consists of four basic functional subdivisions: (1) acquisition, (2) communications, (3) processing, and (4) dissemination or presentation. The basic characteristics of each of these functional subdivisions are:

Data Acquisition

Most meteorological data are acquired and collected by the NWS, FAA, DoD, air carriers, and contract observers. Included are surface observations, upper air soundings, and radar data. The FAA takes about 30 percent of the surface observations within the continental United States. The FAA also distributes Pilot Report (PIREP) information nationwide and provides the majority of weather radar coverage in the Western U.S. DoD provides both surface and upper air data at selected locations, while the National Environmental Satellite Data and Information Service (NESDIS) is the source of all available satellite weather information for civil use.

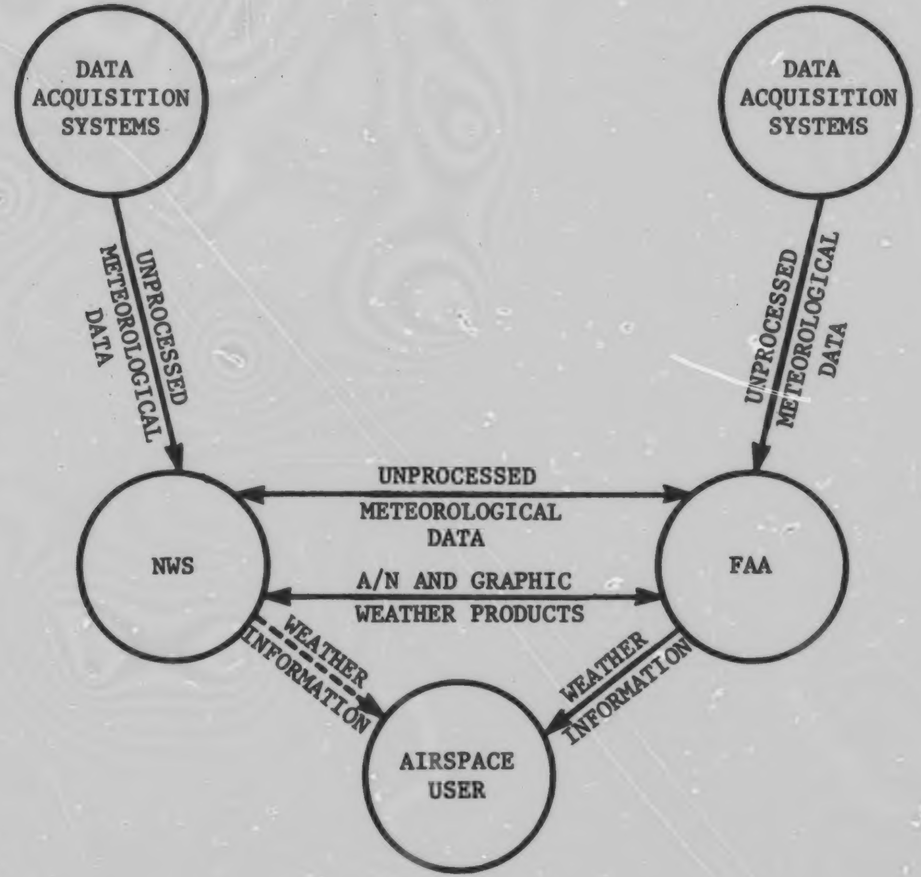
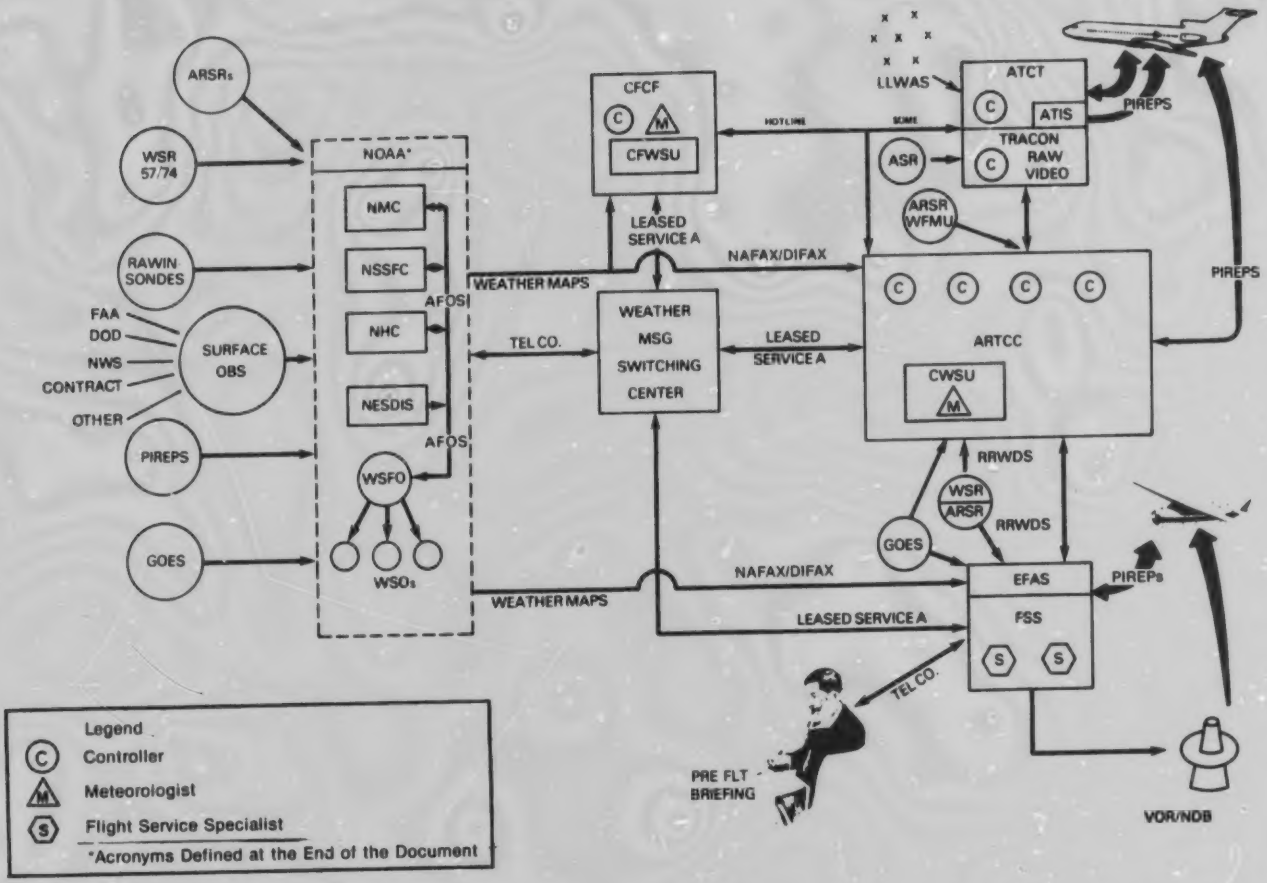

DATA ACQUISITION SYSTEMS
DATA ACQUISITION SYSTEMS
UNPROCESSED METEOROLOGICAL DATA
UNPROCESSED METEOROLOGICAL DATA
NWS
FAA
UNPROCESSED METEOROLOGICAL DATA
A/N AND GRAPHIC WEATHER PRODUCTS
WEATHER INFORMATION
WEATHER INFORMATION
AIRSPACE USER

FIGURE 2-1
LOGICAL LINK BETWEEN VARIOUS PARTICIPANTS IN CURRENT AVIATION WEATHER SYSTEM


ARSRs
WSR 57/74
RAWIN SONDES
FAA
DOD
NWS
CONTRACT
OTHER
SURFACE OBS
PIREPS
GOES
NOAA*
NMC
NSSFC
NHC
NESDIS
AFOS
AFOS
WSFO
WSOs
CFCF
C
M
CFWSU
LEASED SERVICE A
WEATHER MAPS
TEL CO.
WEATHER MSG SWITCHING CENTER
LEASED SERVICE A
NAFAX/DIFAX
HOTLINE
SOME
LLWAS
ATCT
C
ATIS
PIREPS
TRACON
ASR
C
RAW VIDEO
ARSR WFMU
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C
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ARTCC
CWSU
M
PIREPS
RRWDS
WSR
ARSR
RRWDS
GOES
NAFAX/DIFAX
WEATHER MAPS
LEASED SERVICE A
EFAS
FSS
S
S
PIREPs
TEL CO.
PRE FLT BRIEFING
VOR/NDB
Legend
C Controller
M Meteorologist
S Flight Service Specialist
*Acronyms Defined at the End of the Document

FIGURE 2-2
CURRENT AVIATION WEATHER NETWORK

Surface, upper air, and radar data acquisition are still labor intensive activities with the human observer being responsible for taking the observations, interpreting, reducing, encoding the data, as required, and entering it into the communications network. Although in recent years 80 percent of the upper air data acquisition function has been automated by the NWS through the application of minicomputers, observations are still taken only twice daily.

Communications

On the national level, meteorological data are transmitted on medium-speed Leased Service A, a low-speed teletypewriter network, and on a slow-speed facsimile system, aided by interphone communication links. The center of the Aviation Weather System's communications network is the Weather Message Switching Center located in Kansas City. This switching facility serves as the gateway for the flow of alphanumeric information between the various FAA facilities, NWS, and other users (e.g., DoD, air carriers.

In spite of advances being made in the data acquisition area, some system delays could occur when weather conditions change rapidly. Many circuits are running near capacity, and operationally significant products may be delayed during bad weather conditions.

A significant improvement in alphanumeric communications was realized by the implementation of the Weather Message Switching Center and, lately, the Leased Service A System. However, NWS distribution of most weather graphic information to non-NWS users is still accomplished via facsimile, which is costly and time consuming. Some NWS weather facsimile circuits are also running at full capacity. The NWS is in the process of upgrading the National Facsimile Network (NAFAX) and the Digital Facsimile System (DIFAX) to a satellite-based system. The NWS is currently testing and evaluating the products transmitted by satellite with the intent of implementing the new system nationwide by the end of 1986.

Data Processing

The National Meteorological Center, the Air Force Global Weather Central and Fleet Numerical Oceanography Center process meteorological data to generate weather products. Due to the time required to transmit data to these facilities, process the data, and then receive the results back at the user facilities, few of the generated products are suitable for real-time operational application. Meteorological data processing capability in today's system is not capable of meeting the requirements for weather products pertaining to real-time air traffic control operations. Data store/forward functions, as performed by both the WMSC and NMC, are not considered to be meteorological data processing.

Other components of the National Weather Service generate products specifically for aviation. These are generally more timely and useful for real-time application. Aviation forecasts come from 52 Weather Service Forecast Offices, using the guidance products produced by the National Meteorological Center and the National Severe Storms Forecast Center. These offices also prepare approximately 500 Terminal Forecasts three times a day for specific airports in the United States and the Caribbean. They also prepare 327 route forecasts and 40 weather synopses. The National Aviation Weather Advisory Unit in Kansas City, MO, prepares Aviation Area Forecasts for six areas in the conterminous United States three times a day. This unit also produces Significant Meteorological Information Advisories (SIGMETs and Convective SIGMETs) and Airman's Meteorological Information Advisories (AIRMETs) throughout the day.

Presentation

In today's system, nearly all weather information is presented to pilots through telephone or face-to-face briefings, commercially supplied briefings (usually via some type of computer terminal or telephone), or in the case of commercial operations, through their respective dispatch/operations offices. In FAA field facilities that provide weather services, textual and graphic weather products are received via computer terminal (Leased Service A), some teletype and line printer circuits, and the National Facsimile circuits. These products are sorted, posted and updated manually and are available for review by pilots who visit these facilities. General aviation pilots, for the most part, do not have direct access to weather charts and products unless they subscribe to commercial weather services.

Radar weather data are presented on the Air Route Traffic Control Center (ARTCC) controllers' Plan View Display (PVD) as a series of radar radial lines representing a moderate level of intensity return and a series of "H's" outlining high intensity storm returns. In the Terminal Radar Approach Control (TRACON), strong precipitation areas are indicated by "punch through" in the Data Entry and Display System. "Punch through" represents weather reflectivity returns strong enough to override the suppression circuits in the radar. The recently implemented Radar Remote Weather Display System is intended to provide the Center Weather Service Units (CWSU) of the ARTCCs and the En Route Flight Advisory Service (EFAS) locations, color display of weather data directly related to six levels of weather radar reflectivity intensity.

CURRENT AVIATION WEATHER SYSTEMS IN THE AIR ROUTE TRAFFIC CONTROL CENTERS

The operation of the current Aviation Weather System in the Air Route Traffic Control Centers is described below. The system includes the Center Weather Service Unit functions, radar weather inputs, pilot reports, routine weather, and observations.

Center Weather Service Units and Central Flow Weather Service Unit

The FAA has established the CWSU as the focal point for professional meteorological services within the Air Route Traffic Control Centers. After assimilating the available meteorological data, the CWSU meteorologist provides real-time weather information to the controllers at the center and other facilities within the center's jurisdiction. The technical expertise of the CWSU meteorologist is complemented by the aviation and area knowledge of the CWSU Weather Coordinator.

The primary functions and responsibilities of the CWSU are:

1. Meteorological advice and consultation to center operations personnel and other designated FAA ATC facilities, terminals and Flight Service Stations (FSS) within the ARTCC area of responsibility.

2. Assist in efficient collection, screening, editing, and distribution of PIREPs from aircraft in the center's area of responsibility. Solicit PIREPs from aircraft in the vicinity of significant weather.

Information provided by the CWSU is developed through analysis and interpretation of available weather data. The CWSU obtains a comprehensive set of National Weather Service products including Aviation Area Forecasts, Terminal Forecasts, Significant Meteorological Information

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Advisories, Airman's Meteorological Information Advisories, and other aviation in-flight advisories and warnings. This information is provided in the form of briefings and other weather products (forecasts and nowcasts).

1. Briefings - Generally consist of a forecast of weather conditions pertinent to the ARTCC area during a specified period, plus an extended outlook. Briefings are scheduled and provided as required by the facility manager.

2. Meteorological Impact Statement (MIS) - An unscheduled planning forecast describing conditions which could be expected to begin within four to twelve hours which will, in the forecasters judgment, impact the flow of traffic within the ARTCC area.

3. Center Weather Advisory (CWA) - An unscheduled air traffic and aircrew advisory statement which is generally a nowcast for conditions currently in existence or beginning within the next two hours. A CWA may be issued to supplement or redefine an existing SIGMET.

Similar to CWSUs in the ARTCCs, there is a Central Flow Weather Service Unit (CFWSU) located in the Central Flow Control Facility (CFCF) in the FAA Headquarters as a part of Air Traffic Control Command Center (ATCCC). The CFWSU consists of NWS meteorologists assigned to CFCF for the purpose of providing consultation and advice for use by the staff of the ATCCC concerning weather conditions that may adversely affect the National Airspace System (NAS) during the next 24-hour period. This support is provided through detailed briefings of current and forecast weather several times a day.

Although the establishment of CWSU and CFWSU has had a positive impact on the availability of relevant and vital weather information in the ARTCCs and CFCF, because of the slow communications and mode of operations, the products and information generated by the meteorologists are not as timely and accurate as is desired.

Radar Weather Data

Air Route Surveillance Radar (ARSR) weather information processed in the Weather and Fixed Map Unit is presented to the en route controller on the sector Plan View Display in the form of radial lines depicting the location of precipitation areas. The alpha-character "H" indicating hard cores or cells is displayed on the PVD when cell intensities exceed a predetermined level.

Pilot Reports (PIREPs)

The reporting of hazardous, as well as routine in-flight weather information is accomplished on a sector radio frequency. PIREPs are normally forwarded from the sector by controller or supervisory personnel for transmission on Leased Service A. Some area PIREPs are passed informally to and from the terminal ATC facilities via the interphone. Incoming Service A PIREPs are manually delivered to the affected sector. Because of workload limitations, processing and manual handling, dissemination of PIREPs is frequently inadequate. Although improvement in PIREP handling has resulted from the implementation of the En Route Flight Advisory Service and Leased Service A, there is a need for automated acquisition, processing, and dissemination of PIREPs.

Routine Weather Data

Surface observations, forecasts, advisories, Notice to Airmen (NOTAM), etc., are received via Leased Service A by the CWSU meteorologists, and a 100 wpm weather data circuit is interfaced into the 9020 computer. Four weather observation reports can be displayed on the Procedural controller's or "D" sector Computer Readout Device (CRD) and six station altimeter settings on the Radar controller's or "R" CRD. These sector selectable weather reports are automatically forwarded from the WMSC to the ARTCC 9020 computer and then displayed on the appropriate CRD. Additional reports in lieu of those being displayed may be requested through use of the sector keyboard. A hardcopy weather report printout on the flight strip printer may also be requested.

Paper copies of routine weather information, forecasts, NOTAM, and flow control messages are normally kept on shared clipboards posted at the supervisory "E" desk for use by the assistant chief, flow controller, military liaison officer, data systems specialist, and the system engineer.

Radio and Interphone Communications

The use of radio and interphone to distribute information other than for Air Traffic Control purposes is held to a minimum.

Exceptions to this procedure are the exchange of hazardous weather information, as well as the navigational aid and radar malfunction information.

CURRENT AVIATION WEATHER SYSTEMS IN TRACONS/TOWERS

This subsection describes the operation of the current Terminal Radar Approach Control (TRACON)/tower weather system. The operations covered include radar weather data, PIREPs, routine weather data, radio and interphone communications, and Automatic Terminal Information Service (ATIS).

Radar Weather Data

Airport Surveillance Radar (ASR) weather information used by the TRACON controller is primarily unprocessed, broadband radar presented on an Automated Radar Tracking System (ARTS) display, or, at some airports, on a nonautomated ASR display. ASR weather information used by the tower controller is unprocessed, scan-converted, broadband radar presented on a TV Bright Radar Indicator Tower Equipment (BRITE). The radar data are normally derived from a local ASR but, in some cases, the information is obtained from a remote ASR via microwave link.

Pilot Reports

Hazardous and routine in-flight weather information is reported on the approach control or tower radio frequency. Hazardous weather and aeronautical data of significance are broadcast on the Automatic Terminal Information Service at some airports thereby providing recorded distribution of terminal area weather and PIREPs. Intrafacility distribution of PIREPs is either handwritten on a piece of paper and then posted on the position console, or transmitted by word of mouth from position to position, or handled by a video display system at selected facilities. PIREPs filed with the Flight Service Stations get to the TRACON/tower by interphone or the electrowriter systems. Normally, PIREPs received by terminal facilities are passed to the Flight Service Station for editing and transmission; however some terminal area PIREPs are passed to the ARTCC via interphone.

Routine Weather Data

Most Air Traffic Control Towers receive on-site weather observations provided by Limited Aviation Weather Reporting Stations (LAWRS) or by the NWS/FSS via electrowriter. Distribution and display of weather data varies from one

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location to the other but, normally, is in the form of paper. Paper copies of forecasts, NOTAM, flow control messages, etc., often are kept on a clipboard located at the supervisor's desk. Individual direct readout instruments providing wind, altimeter, and Runway Visual Range (RVR) data are used by TRACON/tower controllers to advise pilots by radio of existing values for these parameters. Information on wind shear conditions is provided by the Low Level Wind Shear Alert System (LLWAS). At nontowered airports, weather information is provided by Supplementary Aviation Weather Reporting Stations (SAWRS).

Radio and Interphone Communications

The use of radio and interphone for other than Air Traffic Control purposes is held to a minimum. Local weather/NOTAM information is normally broadcast on the ATIS; however, during certain periods of rapidly changing or deteriorating weather, or during equipment outages, direct radio communication is used to inform the pilot of weather conditions. Direct readout information, such as wind speed/direction, altimeter, RVR and runway visibility, is relayed to the pilot as required by the situation. Pilots requesting routine weather (other than the ATIS information) are normally directed to contact a Flight Service Station on another frequency for the information. Distribution of weather information to terminal controllers is made by the CWSU meteorologist via interphone.

Automatic Terminal Information Service

This service is provided at most major airports to inform pilots, as they approach the terminal area, of the current weather and other pertinent local airport information. In addition, some airports have a departure ATIS that is used by pilots for the same purpose prior to takeoff. A controller records the latest information on an ATIS tape. The information is then transmitted continuously on a discrete radio frequency. In some facilities, personnel in the TRACON have the responsibility to update the ATIS, while other facilities give this task to personnel in the tower. Some locations have the capability to update and control the ATIS from both the TRACON and the tower.

Low Level Wind Shear Alert System (LLWAS)

This system provides pilots and controllers with information on potentially hazardous surface wind conditions (on or near the airport) that create unsafe landing or departure conditions. The system is a real-time, computer controlled, surface wind sensor system which uses telemetry as a communications link and minicomputer processing to evaluate wind speed and direction from sensors on the airport periphery with center field wind data. A 15-knot vector difference triggers an aural and visual alarm in the airport control tower. During the time that the alert is posted, air traffic controllers provide wind shear advisories to all arriving and departing aircraft. At present, 70 systems are in operation and an additional 40 systems are now being delivered and will be installed by 1986. The FAA is evaluating an enhanced Low Level Wind Shear Alert System at New Orleans with twice the number of remote wind sensors to detect microbursts. In addition, an enhanced Low Level Wind Shear Alert System has been recently installed and is operating at Denver Stapleton Airport. The Navy has a prototype Low Level Wind Shear Alert System operating at the Naval Air Station, Patuxent River.

FLIGHT SERVICE STATIONS (FSS)

At present, the FAA maintains a system of 314 manned Flight Service Stations within the U.S. The FSS's primary functions are:

- Preflight and in-flight weather and aeronautical briefings;
- Filing of flight plans;
- Air/ground radio contacts for weather and flight plan information and emergency assistance;
- The acquisition, editing, and distribution of aviation weather PIREPs and NOTAMs;
- The issuance of NOTAMs describing the status of airports, navigation aids, and communication outlets and facilities;
- Flight planning assistance; and
- Conducting search and rescue via communication networks.

Preflight briefings are conducted both in person and by telephone to individual pilots. These briefings provide the pilot with the latest observed and forecast weather, current pilot reports, the general flying conditions, and the status of airports and navigation aids along the planned route of flight. If actual or forecast weather conditions indicate that VFR flight conditions are doubtful, the Flight Service Station specialist will advise the pilot that VFR flight is not recommended.

In-flight weather briefings are provided by radio from the Flight Service Stations. The En Route Flight Advisory Service position collects and disseminates PIREPs and provides en route weather information when requested. Observed and forecast weather information for these briefings are obtained from, but not limited to, Leased Service A, weather facsimile charts, and Radar Remote Weather Display Systems.

Flight Service Stations broadcast Significant Meteorological Information Advisories and Airman's Meteorological Information Advisories periodically during their valid period when they pertain to the area within 150 nm of the station. A SIGMET is an advisory to pilots on weather that is potentially hazardous to all categories of aircraft (e.g., thunderstorms, severe turbulence, and severe icing). An AIRMET is an advisory to pilots on weather that is potentially hazardous to single engine and light aircraft (e.g., extensive fog, icing, moderate turbulence, sustained surface winds exceeding 30 knots, and extensive mountain obscurement). Pilot Automatic Telephone Weather Answering Service (PATWAS) is a continuous telephone recording of available weather data prepared by an FSS specialist. The information given over the telephone contains a weather synopsis, flight precautions, cloud cover, visibility, turbulence, icing, and winds aloft forecasts. The tape recordings of Transcribed Weather En Route Broadcasts (TWEB) are also produced by the FSS specialists. The information contained in these broadcasts are the same as in PATWAS, with the addition of radar reports, surface observations, pilot report summaries, and unpublished NOTAMs.

The Hazardous In-flight Weather Advisory Service (HIWAS) provides a continuous broadcast of hazardous weather advisories over the selected Very High Frequency Omnidirectional Range (VOR). HIWAS will be expanded by simultaneously commissioning all HIWAS broadcast facilities within an ARTCC area. HIWAS in Miami, Jacksonville and Houston ARTCC airspace is now commissioned. Nationwide implementation will follow on a center by center basis.

3. WEATHER INFORMATION REQUIREMENTS

The airspace users include domestic and international air carriers, general aviation, air taxi and commuters, helicopter and military pilots, and the operators of aircraft used for agriculture and forest fire management. The aviation support personnel requiring weather information include airline dispatchers, FSS specialists, air traffic controllers, and meteorologists. Specific weather information requirements for all categories of users are detailed in Appendix B. The following is a concise summary of general weather information requirements as expressed by these users.

Pilot Requirements

Domestic Flights (Civil and Military)

Pilots need the following weather-related information for preflight planning and en route operations:

- Current and Forecast Weather
  - Area synopsis/outlook
  - Observations at departure and destination airports
  - Density altitude
  - Clouds/sky cover
  - Visibility, present weather
  - Winds and temperatures aloft
  - Pilot reports
  - Radar summaries
  - Terminal Forecasts (FT), Area Forecasts (FA), and route-oriented forecasts
  - Weather depiction charts-Visual Flight Rules (VFR)/VFR Not Recommended
  - Runway Visual Range (RVR)
- Severe Weather
  - Airman's Meteorological Information Advisories
  - Significant Meteorological Information Advisories, and Convective SIGMETs
  - Military Weather Advisories and Point Weather Warnings from the Air Force Global Weather Central
  - Convective activity (type and intensity)
  - Icing and turbulence conditions
  - Low level wind shear information

- Information on the presence of lightning
- Marked mountain waves

While en route, pilots need winds aloft updates, current surface observations for intermediate and destination airports, and warnings of severe weather along their route of flight. Helicopter operators need current and accurate information on winds and icing conditions at very low altitudes (at or below 5,000 ft.).

Weather Data Requirements for Oceanic Flights

In addition to the weather data needs listed for domestic flights, the following weather data requirements have been specified in the International Civil Aviation Organization procedures for oceanic flights.

SIGMETs should give specific information on hazardous en route weather phenomena that include the occurrence, and/or expected occurrence, of one or more of the following weather-related phenomena at subsonic and transonic aircraft cruising levels:

- Active thunderstorms
- Revolving tropical storm
- Severe squall line
- Heavy hail
- Moderate and severe turbulence
- Moderate and severe icing
- Marked mountain waves
- Cumulonimbus clouds (at transonic levels)

Weather Information Requirements for Sea-Based Naval Operations

In addition to the weather data needs for domestic flights, additional information on following parameters is required for low-level over water operations.

- Wave height, period, and direction data
- Sea-ice accretion data
- Winds-over-the-deck
- Synoptic and mesoscale wind forecast essential for aircraft carrier (and other sea-based) operational flight planning.

Aviation Support Personnel Requirements

Airline dispatchers need the following weather products:

- Surface weather analysis and prognosis charts
- Radar summary charts
- Satellite pictures
- Severe weather outlook charts
- Freezing level charts
- Constant pressure charts
- Surface temperatures (maximum/minimum) forecast charts
- 400-70 millibar significant weather charts
- Surface observations
- Terminal and Area Forecasts
- SIGMETS and Convective SIGMETS
- Pilot reports
- Winds aloft information
- Low level wind shear information

FSS specialists require the following weather information:

- Airport surface observations
- Terminal Forecasts
- Area Forecasts
- Route-oriented and hazardous area forecasts
- Weather radar data
- Geostationary Operational Environmental Satellite data
- Pilot reports
- Low level wind shear information
- Weather depiction charts

In addition, these specialists need automated route-oriented data retrieval and display aids for preflight briefings and en route assistance to the pilots.

Air traffic controllers need the following weather information:

- Airport surface observations
- Terminal Forecasts
- Area Forecasts
- Low-level wind shear information
- Winds aloft information
- Hazardous weather areas (nowcasts of thunderstorms, tornadoes, hail, precipitation and turbulence)
- Pilot reports

Meteorologists in The Center Weather Service Units need the following weather information:

- Airport surface observations
- Aviation weather forecasts (Terminal and Area Forecasts)
- Weather radar data and charts
- Information on hazardous weather areas
- Satellite data
- Winds aloft information
- Low level wind shear information
- Automated route oriented data retrieval and display aids for en route assistance to pilots
- Surface weather analysis and prognosis charts
- Surface weather outlook constant pressure, surface temperature and significant weather charts
- Pilot reports
- Automated aids to collect, process, and disseminate weather information to Air Traffic Control facilities

A matrix of users vs. weather information requirements is presented in Table 3-1.

TABLE 3-1
USER AVIATION WEATHER INFORMATION REQUIREMENTS**

Weather Information and Products Users	Area Forecast & Route Forecast	Surface Observation	Terminal Forecast	Winds & Temperature Aloft	PIREPS	Convective Activity Heavy Precip & Thunderstorms	Ice & Freezing Rain	Turbulence	Area Synopsis/Outlook	AIRMETS, SIGMETS Convective SIGMETS	Embedded Thunderstorm	Squall Lines	Surface Weather Prognosis	Radar Summary Charts	Satellite Picture	Severe Weather Outlook Charts	High Level Severe Weather Info	Wind Shear	Areas of Occurrence and Size of Hail	Hazardous Wake Turbulence	Short-Term Forecasts of Wind, Pressure, Cloud Cove, and Icing	Tropical Revolving Storm	Marked Mountain Waves	Special Airport Surface Observations	TWEB	Severe Weather Watch Bulletins	Special Flight Forecasts	Weather Depiction Charts	Radar Weather Reports	Significant Weather Prognostics	Freezing Level Charts	Constant Pressure Charts	Constant Pressure Prognostics	Lightning Detection	Wave Height, Period, Direction	Winds-Over-The-Deck	
GA Pilot	X	X	X	X	X	X	X	X	X*	X	X*	X*	X	X	X			X*	X	X	X	X	X	X	X	X		X	X	X	X			X			
Air Taxi/ Commuter Pilot	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X	X			X			
Air Carrier Pilot	X	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	X	X	X		X		X	X	X				X			
Helicopter Pilot	X	X	X	X	X	X	X	X	X	X	X	X	X	X				X	X	X	X	X		X	X	X		X	X					X			
Airline Dispatcher	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X	X			
Oceanic Flight	X	X	X	X	X	X	X	X		X	X	X					X	X	X		X	X	X	X	X					X		X	X				
FSS Specialist	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Controller	X	X	X	X	X	X	X	X		X		X					X	X	X	X			X	X		X											
CWSU Meteorologist	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X				X	X	X	X	X	X		X	X	X	X	X	X	X	X		
Agriculture	X	X	X	X	X			X		X		X	X								X					X								X			
Forestry	X	X		X	X	X	X	X		X		X	X								X			X	X	X			X					X			
Air Force		X	X	X	X	X	X	X		X	X	X	X	X	X			X		X	X		X	X		X		X	X	X	X	X	X	X			
Navy		X	X	X	X	X	X	X		X	X	X	X	X	X			X		X	X		X	X		X		X	X	X	X	X	X	X	X	X	

*For Business Flights
**Expressed by Users

4. AVIATION WEATHER SYSTEM REQUIREMENTS

As a result of significant consultation with the aviation community, a complete range of weather information requirements is highlighted in Table 3-1. As shown in the table, most pilots need accurate surface observation and winds aloft data, Terminal and Area Forecasts, PIREPs, and timely information on hazardous weather conditions such as wind shear, thunderstorms and icing. In order to provide the needed improvements to the current system and to meet future requirements of aviation weather users, the Aviation Weather System needs to be structured to provide phased changes in the existing system with minimal disruptive impact on the users.

The improved Aviation Weather System must provide more accurate, reliable, and complete information, rapidly disseminated to the users in operationally suitable formats. The system should reduce the adverse impact of weather phenomena through enhanced hazardous weather detection and communication systems. It should also provide direct pilot access to weather data, and minimize the controllers' role in the weather data dissemination function. Presented in the following paragraphs are generic requirements for the Aviation Weather System pertaining to data acquisition for routine and hazardous weather, information processing and forecasting, and product dissemination.

Aviation Weather Observations

- Provide increased frequency of aviation weather observations (compared to the existing system) and improve quality and availability of data through automation and quality control.
- Develop a network of automated weather observing systems to provide real-time data for generating Terminal and Area Forecasts.
- Identify the system, or a combination of systems, to cost effectively meet the site-specific observation requirements.
- Provide Air Traffic Control positions with an ability to display required surface observations (automatically updated).

- Provide automated dissemination of real-time aviation weather observation data from selected reporting points to airspace users.

Winds and Temperatures Aloft

- Enhance data base to provide accurate temperatures and winds aloft, updated as required, capable of system interpolation for any intermediate point (location and/or altitude).

- Provide the Aviation Weather System with the capability of receiving and processing wind data from sources such as the Profiler, satellite, or appropriately equipped aircraft.

- Improve models for forecasting upper winds.

- Display controller-selected alphanumeric upper wind data up to 60,000 ft., in 1,000 ft. increments up to 29,000 ft., and every 2,000 ft. between 29,000 and 60,000 ft. (automatically updated).

Detection, Tracking and Display of Hazardous Weather

- Improve radar detection and tracking of hazardous weather, i.e., heavy precipitation, hail, freezing rain, icing, and snow.

- Provide timely detection of hazardous weather such as thunderstorms, turbulence, wind shear (microbursts, gust fronts), hurricanes, tornadoes, and lightning.

- Provide early detection and identification of wind shear phenomena within a defined airport region, displayed in real-time at selected positions.

- Provide display of hazardous weather information at the en route positions with reflectivity intensity contours, compatible and consistent with NWS reflectivity levels.

- Provide mosaicked weather radar data selectable by intensity levels in a continuous single display for any area of interest.

- Provide continuous, graphic, radar weather presentation at a dedicated display. Also provide call-up capabilities at a controller display, allowing selected processed weather data to be displayed at the controller's discretion. No control data shall be lost while the weather data are superimposed.

- Provide frequently updated high resolution satellite imagery/data displays.

- Present real-time hazardous weather information at the sector controller display positions, identifying locations of hazardous weather phenomena, such as turbulence, icing, precipitation and convective activity.

- Provide automated display of new hazardous weather information at applicable sectors with an accompanying alert (e.g., flashing light) until acknowledged.

- Provide satellite imagery/data at all Automated Flight Service Station operating positions. The data should be highlighted by system-generated geographical boundary maps; automatically contoured (in the case of infrared data) for temperatures, with the information converted to altitude(s); and displayed by color contouring and/or alphanumerics.

- Support the development of procedures to reduce separation standards through wake vortex avoidance based on measurable meteorological conditions.

Forecasts

- Provide near-term forecasts (0-4 hours) for strategic traffic planning and nowcasts (0-30 minutes) for tactical avoidance of severe weather.

- For Terminal Forecasts, provide adequate automated surface weather observations, weather radar data, satellite imagery/data, local prediction algorithms and terrain knowledge, conventional prognostic surface information (i.e., pressure, fronts, and air masses) and vertical sounding data.

- For accurate Area Forecasts, provide upper air wind and jet stream pattern data generated by the numerical prediction models, observed and prognostic surface information, satellite imagery/data, mosaicked radar data, and pilot reports.

- For generating in-flight advisories (i.e., SIGMETs, Convective SIGMETs, and AIRMETs), provide upper air soundings and wind data, pilot reports, stability charts, and predicted surface charts and winds, in addition to weather radar data and satellite imagery/data.

Improved Handling of Pilot Reports

Provide automated means for collection, entry, processing (screening to avoid duplication), distribution, and call-up of all pilot reports including those generated by DoD.

The capabilities should:

- Facilitate pilot report entry directly from cockpit via data link, from controller positions in Area Control Facilities and by Automated Flight Service Station specialists.
- Provide automated means of correlating information that is already in the system (e.g., latitude/longitude, aircraft type), and minimize keystroke entry of additional data by means of simplifying menu-type programs.
- Provide a selectable graphic or alphanumeric summary of current and previous pilot reports by specific phenomenon, route, altitude, area, location and time.
- Provide automated deletion of PIREPs that are no longer considered appropriate for timely information.

Dissemination

- Provide continuous and rapid transfer of data from sources to the users through data interchange between the various processing functions and electronic interfaces for interfacility communication.
- Provide timely removal/substitution of expired and/or amended information and generate an alert based on adjustable system parameters at specified locations.

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- Provide for automatic update of displayed data at specified positions as defined by adjustable system parameters.

- Provide a capability to rapidly record and broadcast weather information.

- Develop means for generating voice synthesized messages including routine surface observation data and hazardous weather information for broadcasting over VORs.

Pilot Briefings

- Provide automatically generated graphic and alphanumeric data for complete pilot weather briefings along pilot-defined routes or areas. The system should provide these data with a minimum amount of keystrokes, and display the data for an environment defined by adjustable system perameters. System parameters include: route corridor widths, altitudes, radius from geographic location, times, airspeeds, and latitude/longitude coordinates.

- Weather data for complete pilot briefings along defined routes and areas should include:

  1. Overview/synopsis of weather relevant to route/area
  2. Surface observations and Terminal Forecasts for departure/destination/selected alternate airports
  3. Winds and temperature aloft at desired altitudes
  4. Observations and forecasts along the desired route (including airports along the route of flight)
  5. All NOTAMs for departure, destination and alternate airports, and en route NOTAMs (only navigational)
  6. Convective activity
     a. Heavy precipitation
     b. Thunderstorms
     c. Lightning activity
  7. Turbulence amount, type, and altitudes of encounter
  8. Icing type, intensity and freezing level(s).

5. AVIATION WEATHER SYSTEM DEVELOPMENT

The recommendations made by various review committees, user organizations and the National Transportation Safety Board to the Congressional subcommittees as well as the improvements recommended at joint government/industry meteorological workshops, are presented in Appendix A. In response to these recommendations, a number of procedural changes and system improvements have already been made. A set of recommendations that will need major system enhancements are listed below.

- Provide automated surface weather observing systems at airports with instrument approach procedures or with a large number of aircraft operations, at offshore platforms, and at remote heliports.
- Improve upper wind measurements and forecasts for fixed-wing aircraft and wind information at low altitudes for helicopters.
- Provide accurate short-term forecasts for weather avoidance.
- Provide capabilities for preflight direct user access to route-specific computer based weather information.
- Provide real-time detection of hazardous weather phenomena (wind shear, thunderstorms, turbulence and icing conditions) and rapid dissemination of information to the appropriate aircraft and helicopters.
- Provide rapid acquisition, processing and dissemination of pilot reports.

Responding to the above user recommendations, it appears that some requirements can be met by near-term improvements, while others will require major resource expenditure and capital investment to develop elements of the Aviation Weather System. Additional supporting research programs will be needed to satisfy the remaining requirements. The FAA is in the process of implementing services that will improve the distribution of important routine weather information to pilots, FSS specialists, and controllers as well as provide hazardous weather information in real-time.

Since the Aviation Weather System is a subsystem of the National Airspace System, it includes capabilities integrated with other National Airspace System functions to provide more accurate, reliable information, rapidly distributed in directly usable formats to pilots and controllers, in order to significantly improve aviation safety and efficiency. The goals of the future Aviation Weather System are described below in terms of availability of weather information to the system users.

1. Pilots will have ready access to the required weather information during all phases of flight operation.

- Preflight
    - via telephone to either Flight Service Station specialists or the Voice Response System (VRS)
    - via Direct User Access Terminals (DUAT)
    - via telephone to the Automated Weather Observing System
- In-flight
    - via radio to En Route Flight Advisory Service
    - via automatically updated, continuous voice broadcasts
    - via data link
    - from controllers/FSS specialists for nonroutine and hazardous information, as required.

2. Flight Service Station specialists will be provided an improved weather dissemination capability through:

- Automation of the workstation by the Flight Service Automation System Program
- Availability of new products from Center Weather Service Unit meteorologists
- Availability of satellite imagery and Doppler weather radar information.

3. Controllers will have immediate access to weather information including:

- Hazardous weather contours displayed at control positions

- Automatic display of required alphanumeric data - alarms automatically provided for time critical information
- Immediate access to any required data not automatically provided
- Immediate access to the Center Weather Service Unit meteorologist for weather consultations, as required.

4. The Center Weather Service Unit meteorologist will be provided with an automated system with the following capabilities:

- Rapid access to all required weather data and products
- The capability to create and annotate graphic weather products for subsequent display to pilots, controllers, and FSS specialists
- The capability to rapidly disseminate weather products to controllers and pilots
- Special applications processing routines to assist in the analysis of data and automated alarms for significant weather information.

5. The weather data base will contain real-time weather data from:

- Doppler and conventional weather radars
- Automated surface weather and upper air observations
- Improved PIREPs collection and dissemination
- Automated collection of upper air data from aircraft on-board sensors.

6. Appropriate communication links will assure timely distribution of all related data.

Table 5-1 presents a summary of programs that will meet specific Aviation Weather System requirements presented in Section 4. In addition to meeting the weather information needs of the military, the Department of Defense systems such as the Automated Weather Distribution System would also share weather data with the civil users. Described in the following paragraphs is a synoptic summary of the FAA and other agencies ongoing and future weather system development programs that will meet the future weather system requirements.

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TABLE 5-1
AVIATION WEATHER SYSTEM REQUIREMENTS AND RELATED PROGRAMS

REQUIREMENT AREA	FAA PROGRAM	OTHER AGENCY PROGRAM	JOINT FAA AND OTHER AGENCIES PROGRAM
1. Surface Weather Observations and Reporting Service			
Frequent/Accurate Weather Observations Surface Observation Network	AWOS/ADAS*	ASOS (NWS) AWDS, SMOOS (DoD)	JAWOP (FAA, NWS, DoD)
2. Radar Improvements			
En Route Terminal	ASR-9		NEXRAD (FAA, NWS, DoD)
Ground Weather Radar Information in Cockpit	MODE S/Data Link		
3. Display Support			
Center	GOES, CWSU Workstation, RRWDS	NEDS (NAVY), AFOS (NWS)	
Terminal	CWP/Terminal Sector Suite		
CWSU	GOES, CWSU Workstation, RRWDS		
FSS	GOES, RRWDS		
4. Processing and Dissemination			
Concise/Timely Pilot Briefings	FSAS		
Direct User Access	DUAT, VRS		ARF (FAA, NWS)
Weather Data Processing			
National Level	WMSCR, AWP		
Area Control Facilities	FSDPS, CWP, ACCC		
Display Processing for FSS	AFSS		
5. Communication Improvements			
Faster Communication Circuits	NADIN		
Direct Pilot Communication	MODE S/Data Link		
Interfacility Communication	NADIN	AWIPS-90	
6. Upper Wind Measurement and Forecast	MODE S/Data Link/WCP	Profiler (NOAA) VAS and other Sounder	ASDAR (NWS)
7. Short Term Forecasts	Automated CWSU		PROFS, STORM (Mesoscale) AWPTF
8. Improved PIREPs Handling	FSAS, EFAS, Data Link		
9. Real Time Detection and Dissemination of Hazardous Weather			
Wind Shear	Improved LLWAS		Terminal Doppler Weather Radar JAWS (FAA, NOAA, NASA)
Turbulence Thunderstorms/Storm Movement Icing Detection and Forecast	Thunderstorm and Icing Environmental Characterization		NASA Research NEXRAD, PROFS
Lightning Detection	AWOS		Lightning Detection Systems
Real-Time Dissemination	HIWAS		

*Acronyms are defined at the end of the document

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NEAR TERM ACTIVITIES

Center Weather Service Unit Improvements

FAA has provided all Center Weather Service Units with the Leased Service A System to enable them to more rapidly access the alphanumeric weather data base and to input pilot reports to the system. Telephones with autodial capability have also been provided to facilitate the dissemination of hazardous weather to towers and EFAS locations within the center's area of control responsibility. The Radar Remote Weather Display System digital weather radar provides area wide precipitation intensity information. New products now available from the Center Weather Service Unit include Meteorological Impact Statements and Center Weather Advisories. A Meteorological Impact Statement is an unscheduled planning forecast which describes the adverse weather conditions for the Air Route Traffic Control Center, Central Flow Weather Service Unit, Center Flow Control Facility, and hub terminal air traffic facility specialists responsible for making flow control related decisions. It enables these specialists to include the impact of expected, specified local and/or national weather conditions in making these decisions. A Center Weather Advisory is an unscheduled weather advisory. It is issued for the guidance of Air Route Traffic Control Center personnel, designated FAA facilities, Central Flow Weather Service Unit meteorologists, and air crews in flight to anticipate, or avoid, adverse weather conditions in terminal and en route environments. A national standard operating practices document has been published for the Center Weather Service Units by the FAA and the National Weather Service.

High Altitude En Route Flight Advisory Service

High altitude aircraft frequently interfere with lower altitude aircraft attempting to utilize the EFAS. To remedy this, FAA is implementing separate frequencies for use by aircraft above Flight Level 180. High Altitude - En Route Flight Advisory Service (HA-EFAS) will provide a discrete frequency for each of the 20 ARTCC areas in the continental United States. The location of all ninety-six outlets have been identified by FAA regional offices. Transmitters, receivers, consoles and related equipment are in FAA stock and available for installation. Funding for the installation has been approved for fiscal year 1985.

Expansion of Leased Service A System

The FAA began implementing the Leased Service A System several years ago to replace the teletype equipment at high activity Flight Service Stations. This program was expanded to include all Flight Service Stations and Center Weather Service Units within the conterminous United States and in Alaska. This program was completed in 1984 through the replacement of the low speed Service A teletype system with the medium speed Leased Service A.

New Pilot Briefing Procedures

The FAA has introduced new procedures which make it easier for pilots to get the type of briefing that best serves their needs and reduce the time required to obtain weather information. There are three specific types of briefings available:

- Standard Briefing. Includes adverse conditions, synopsis, current conditions, en route and destination forecasts, winds aloft forecast, NOTAMs and known ATC delays. Military training activity and other data will be provided on request.
- Abbreviated Briefing. Designed to supplement data the pilot already has. Briefer will have to be told what information has been obtained and how long ago.
- Outlook Briefing. Intended primarily for planning purposes if departure time exceeds 6 hours. Briefer will provide forecast data applicable to the proposed flight.

Radar Remote Weather Display Systems

The FAA, in conjunction with the NWS, completed the installation of 134 Radar Remote Weather Display Systems, 77 on NWS weather radars and 57 on FAA long-range radars. These digitizers provide a six-level color display of precipitation reflectivity intensity for use at Center Weather Service Units and En Route Flight Advisory Service locations. Radar Remote Weather Display Systems are also available at 30 Navy/Marine Corps locations in the CONUS.

Hazardous In-flight Weather Advisory Service

This service is designed to make SIGMETs, Convective SIGMETs, and AIRMETs available to airborne pilots through continuous

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broadcasts over selected VORs. The concept was demonstrated in the Miami and Jacksonville Center areas using 13 VOR outlets for area coverage; recorded broadcasts were continuously updated by 11 Flight Service Stations to provide information at 4,000 feet and above, over the two Centers areas. The FAA is in the process of implementing this service nationwide, with Miami, Jacksonville and Houston currently operational.

Airport Surveillance Radar-9

The weather channel on the Airport Surveillance Radar (ASR-9) will provide displays of two of the six available radar reflectivity intensity levels for the terminal area users.

Low Level Wind Shear Alert System Implementation

This is an ongoing program which, when completed, will provide 110 systems. There are 70 systems presently in operation. Forty additional systems will be implemented by early 1986.

In order to enhance the capabilities of the existing Low Level Wind Shear Alert Systems already in operation, the FAA is studying ways to enhance the capability of these systems to detect microburst phenomena. The FAA is also conducting research on wind shear to improve the Low Level Wind Shear Alert System. The Joint Airport Weather Study is a joint effort between FAA, NOAA, NASA and National Science Foundation. An array of Doppler radars, automated surface observations, radiosondes, lightning detection systems, and instrumented aircraft were used to detect and measure weather hazards to aircraft. Data were gathered during 1982 in the area near Denver, Colorado. Hazards included wind shear, downbursts, microbursts, heavy rain, and thunderstorm-associated weather. The FAA is funding for the continued analysis of these data which is expected to provide information for inclusion in the NEXRAD specifications and recommendations for siting the Terminal Doppler Weather Radars. These data will also be used to assist in the development of improved Low Level Wind Shear Alert System siting criteria and to improve wind shear models for use in flight training simulators.

New Orleans Enhanced System

Using siting criteria generated by the Joint Airport Weather Studies (JAWS) Project, the FAA has doubled the number of remote wind sensors (from 5 to 10) in an effort to detect microbursts with a higher density anemometer network.

The enhancements include a data collection capability which will enable the agency to evaluate the effectiveness of the system. Operational tests began in June 1984 and are expected to continue through 1985. Results of this test program will assist in the definition of Low Level Wind Shear Alert System enhancements.

Denver Enhanced System

An expanded Low Level Wind Shear Alert System, similar to New Orleans, has been installed at the Denver Stapleton Airport. Stapleton experiences an unusually high number of wind shear events, particularly those associated with microburst activity, and this modified system will provide improved sensor coverage. In conjunction with the operational use of the expanded system, the system data will be recorded and analyzed as part of the continuing development of enhanced wind shear detection systems. This corollary effort is being conducted by the Research Applications Program of the National Center for Atmospheric Research and will specifically examine sensor siting criteria, alternative operating and display algorithms, and alternative operational display techniques.

Aviation Weather Forecasting Task Force

A continuing concern of pilots, dispatchers, and other users of aviation weather forecast products is the accuracy and timeliness of these products. Last year, the FAA's Weather Coordination Program staff investigated this problem in detail and found that while there appeared to be near-term improvement options available, there were many institutional constraints standing in the way of implementation. These constraints were, if anything, more prevalent in the user community than in the government. The users are geared to handling products in a certain manner, and change in either the products or their format is costly. Without knowing the degree of improvement to expect, users are reluctant to sign up for new products. The government, on the other hand, is reluctant to work on improvements that no one wants.

One approach to modify this cycle is to have the government identify and quantify the most promising near-term actions, and then to present this information to the users for their consideration and recommendations. This is the rationale behind the establishment of the Aviation Weather Forecasting Task Force. This Task Force, while funded by the Federal Aviation Administration, is a joint Federal Aviation Administration and National Weather Service effort. The Task Force is composed of

10 scientists who are knowledgeable in the areas of weather forecasting and predictive modeling and who, except for one, are independent of the National Weather Service. They will study today's aviation weather forecast products, the current state of the weather forecasting science, develop recommendadations for near-term improvements, and wherever possible quantify the improvement each recommendation is expected to deliver. The recommendations are to be implementable in a one to three year time frame, since the goal is to improve current products rather than to identify long-term research needs. The Task Force held its first meeting on November 15, 1984, and has 18 months to complete the work. However, it is anticipated that recommendations will be made available for consideration as they are completed by the Task Force.

Three-Level Weather Project

The FAA is planning to provide three-levels of weather on PVD in each Air Route Traffic Control Center. The project consists in having the central computer complex, computer display channel, display channel complex, and Direct Access Radar Channel (DARC) operational software modified to accept three-levels of weather from the CD-2; and ARSR-3 systems will be modified to provide the capability of transmitting three-levels of weather. Low-level will be represented by radial lines, medium-level by "M", and high-level by "H". Field modifications kits will be available beginning in July 1987.

MID/LONG-TERM ACTIVITIES

In this section, FAA's Aviation Weather System development programs and joint programs with other agencies are described in terms of the improvements each system will provide to meet future needs. Various ongoing research activities are also discussed. Requirements for future research are discussed in Section 6. The purpose, approach, products available, and schedules of individual FAA programs discussed in this section, are presented in detail in Section 7. Other agencies' programs are reviewed in the same manner in Section 8.

The programs are:

- Joint Automated Weather Observation Program (JAWOP)
- Automated Weather Observing System (AWOS)
    - AWOS Data Acquisition System (ADAS)
- Automated Surface Observing System (ASOS) - NWS
- Weather Message Switching Center Replacement (WMSCR)

- Flight Service Automation System (FSAS)
    - Flight Service Data Processing System (FSDPS)
    - Automated Flight Service Station (AFSS) System
    - Aviation Weather Processor (AWP)
    - Aviation Route Forecast (ARF) System

- Central Weather Processor (CWP)
- Next Generation Weather Radar (NEXRAD)
- National Airspace Data Interchange Network (NADIN)
- Mode S/Data Link
    - Weather Communications Processor (WCP)

The research activities are:

- Terminal Doppler Weather Radar (TDWR)
- Program for Regional Observing and Forecasting Services (PROFS)
- Airborne Wind Shear Detection Techniques
- National Aircraft Icing Program
- Aircraft Icing Research
- Stormscale Operational Research Meteorology Program (STORM)
- GEM (Generalized Equivalent Markov) Forecasting

Joint Automated Weather Observation Program

The Departments of Commerce, Defense, and Transportation have significant weather observing activities which directly support aviation operations. This program coordinates the activities of these agencies to provide automation of most of the weather elements now being provided by manual observations. A Joint Automated Weather Observation Program Council provides policy coordination and oversight of the multiagency activities designed to meet the national requirements for automated surface weather observing systems. The Council is chaired by the Federal Coordinator for Meteorological Services and Supporting Research and is comprised of a representative from each of the participating Departments. This joint program facilitates the development and acquisition of an automated weather observing capability that will meet common requirements for national weather observations and provide the flexibility to incorporate any unique capabilities required by the individual agencies involved.

Automated Weather Observing System

The Automated Weather Observing System is designed to provide automated surface weather observations at selected airports with instrument approaches and no current weather observations available. The system will become an integral part of the nationwide surface observation network. AWOS data can be provided through various transmission options to pilots, air traffic controllers, Flight Service Station specialists, Center Weather Service Unit meteorologists, and any other users requiring real-time surface weather data. The goal of this program is to improve aviation safety and efficiency, controller and specialist productivity, as well as to reduce the costs of weather data acquisition, and fully meet validated National Airspace System user requirements. Even though it is not currently a requirement, AWOS could be considered in the future as a means to meet special weather observation needs at off-airport locations along high density VFR flyways such as mountains and certain river valleys.

The Automated Weather Observing System is composed of meteorological sensors, a computer processor with appropriate software, a voice synthesizer, and a communication link. The system requirements are such that commercially available hardware/software may meet most of the requirements and specifications. The basic sensors will provide wind, temperature, dew point, pressure (altimeter setting), precipitation intensity, visibility, and cloud height. The processor accepts the outputs from the meteorological sensors then processes, displays, and transmits the information to users through data communications networks, radio broadcast, dial-up telephone ports, and direct readout CRT displays. The system will incorporate an archiving function for post accident analysis of the weather data. The system can be implemented in both an attended or an unattended mode and has the inherent flexibility of modular design to incorporate additional sensor capabilities, as new sensors are developed and proven.

The FAA has conducted a demonstration program and has evaluated the system under different operational and climatic conditions at 14 sites. A preliminary report shows that most pilots found the system useful. The test results indicated that the ceilometer for measuring cloud height and coverage did not give adequate performance, and there were problems associated with the precipitation sensor. Technical solutions now exist to solve the precipitation sensor problem. Presently, design is to merge visibility with precipitation sensors. The improved sensor is also expected to provide information on the type of precipitation. Additional tests are needed to prove the system's efficiency. The format in which the information will be made available is also to be refined. The first installation of a production system is planned for mid-to-late 1987.

AWOS Data Acquisition System (ADAS)

The ADAS will provide the centralized capability for the collection, processing and distribution of surface weather observation data for the Area Control Facility flight advisory area. It will collect data from two types of automated weather observing systems--the Automated Weather Observing System and the NWS Automated Surface Observing System. Processing of surface weather observation data will include such functions as consistency checking, archiving and the generation of special products for the NWS. ADAS will distribute surface observation data and messages to the collocated Flight Service Data Processing System, Central Weather Processor, and to the Weather Message Switching Center Replacement.

Automated Surface Observing System (National Weather Service)

The Automated Surface Observing System being developed by NWS will be a flexible modular system capable of being deployed in various configurations, and will be able to function with or without the attendance of an observer. The system's specific configuration will vary depending upon whether the system is operated in an unattended or in an attended mode by the observers, who provide a minimum level of added information by way of remarks appended to output messages. When the system is fully automated with an extensive set of sensors, it can operate in a stand-alone mode. In all cases, the system will handle all the clerical tasks of local archiving, maintaining the observer's log and summaries, and formatting the data in various codes for distribution. More importantly, the system will provide a continuous weather watch (which is not now possible) at NWS sites.

- Basic-Level Unattended Automated Surface Observing System

  In this mode of operation, the system will automatically provide observed data of the essential weather parameters needed for flight operations and for generating most of the forecasts. Typical observed parameters are:

  - Wind speed and direction
  - Temperature and dew point
  - Pressure
  - Visibility (to 8 miles)

- Limited present weather (e.g., freezing rain, precipitation yes/no determination, thunderstorm detection)
- Precipitation accumulation
- Sky condition (up to 10-12,000 ft.)

- Basic-Level Attended Automated Surface Observing System

  The system operation in this mode will be exactly the same as in the unattended mode with the exception that the attending observer will augment the observations produced by the automated system by providing additional information on present weather conditions.

- Fully-Automated Surface Observing System

  This system will operate in an unattended mode to automatically observe and report the full range of weather parameters. The system's additional sensor and processing capabilities beyond that of a basic ASOS are:

  - A present weather sensor (e.g., Laser Weather Identifier) for detection and discrimination of precipitation type and character
  - Extra ceilometers and visibility sensors (at selected locations and as necessary to recognize and report nonhomogeneous conditions)

Weather Message Switching Center Replacement

The Weather Message Switching Center Replacement will replace the existing Weather Message Switching Center (WMSC) with state-of-the-art equipment and technology to perform all of the current functions of the WMSC, except Notice to Airmen processing which will be handled by the Consolidated NOTAM System (CNS). The WMSCR will be able to manage both graphic as well as alphanumeric data, which is an increase in capability over the current system. The replacement will serve as the sole gateway to the National Meteorological Center and, therefore, will be the source of National Weather Service Products for the National Airspace System. The WMSCR will also handle Aviation Route Forecast System products. It will provide procedural transparency for present WMSC users and rely on the National Airspace Data Interchange Network for circuit connectivity. Other users and organizations requiring weather information will be capable of receiving it by accessing the WMSCR via the NADIN node closest to their facilities. Identical WMSCR nodes will be collocated with the NADIN system switch nodes in Salt Lake City, UT and Atlanta, GA, to provide geographic redundancy. Each WMSCR node will have the capability of distributing products for the entire system in the event of a failure at one of the nodes.

Flight Service Automation System

The objective of the Flight Service Station Automation Program is to meet projected increases in demand for flight services without a proportional increase in staff and operating costs. This will be accomplished by extensive use of automation and the concept of self briefing whereby the users can access the system directly and obtain a weather briefing or file a flight plan.

The program provides for the consolidation of the current 314 Flight Service Stations into 61 Automated Flight Service Stations. Automation will be developed and implemented in three unique steps - limited automation for FSS specialists, full automation for specialists with limited direct user access, and full direct user access capability. By 1988, pilots will have the capability to directly access the Flight Service Automation System through a variety of self-briefing techniques for preflight and in-flight weather briefings and by 1990, an additional capability will be available for filing flight plans.

The key components of the Flight Service Automation System are the Flight Service Data Processing System which is the main frame processor, the Automated Flight Service Station operator terminals, and the Aviation Weather Processor which is the host for the weather data base.

Flight Service Data Processing System

The Flight Service Data Processing System will automate the Flight Service Station operation with the data processing capability to perform the following functions:

- Data Base Maintenance: Maintain a data base containing all appropriate aeronautical weather information.

- Flight Plan Processing and Dissemination: Flight plans will be entered either through the Automated Flight Service Stations or via the Direct User Access Terminals, and sent either to the ATC System for dissemination or to the destination Automated Flight Service Station.

- Weather Information Processing: Weather information will be received from the Aviation Weather Processor and the Central Weather Processor, and distributed to the Automated Flight Service Stations and other system users via the voice response units and Direct User Access Terminals.

- NOTAM Processing and Distribution: The system will maintain a NOTAM file, and allow these NOTAMs to be accessed by the Automated Flight Service Stations. This NOTAM data base is identical to the one maintained by the Aviation Weather Processor.

Automated Flight Service Station

Interactive alphanumeric and graphic workstations will be provided for the personnel at the Automated Flight Service Stations. These stations will be connected directly to the Flight Service Data Processing System through leased telephone circuits. Input messages will be either NOTAMs, flight plans, weather data, requests for stored data, or system control messages. The associated outputs will be in the form of acknowledgments to inputs, the requested data (either alphanumeric or graphic), or other system status messages.

Aviation Weather Processor

The Aviation Weather Processor is intended to house, maintain, and process a national weather data base for use by the Automated Flight Service Stations. The system will receive both graphic and alphanumeric data from the Weather Message Switching Centers Replacement, which will receive those products from the National Meteorological Center. It will edit, expand, process, and store these weather data and subsequently distribute them to the Flight Service Data Processing Systems. Weather update information will be received from the Flight Service Data Processing Systems and sent to the Weather Message Switching Centers Replacement for dissemination to other users. In addition to weather processing, the Aviation Weather Processor will receive, store, and distribute NOTAM messages.

Aviation Route Forecast System

An important enhancement to the Flight Service Automation System is the Aviation Route Forecast system which represents a subset of weather information that can be incorporated in the route oriented briefings function. The forecast weather data base needed for this system includes cloud cover (amount, bases and tops), visibility, weather, convective activity, freezing level, winds and temperatures aloft, icing, and turbulence. These area-type aviation weather phenomena are available in today's TWEBs, AIRMETs and Area Forecasts, but are inefficient for route planning purposes. The NWS proposed and internally coordinated a new grid data base concept, the Aviation Route Forecast.

Central Weather Processor

The Central Weather Processor will:

- Accept, contour, and mosaic weather radar data from multiple radars into an image covering the Area Control Facility and Flight Service Data Processing System areas, and disseminate this image or subsets of the image to various users.
- Maintain a data base of weather information applicable to the Area Control Facility, as required by various users, and distribute these data to the various users either automatically or on demand. These data will include: weather radar data; weather satellite imagery; alphanumeric weather information such as observations, forecasts and warnings; and weather graphics.
- Support an interactive, automated workstation that will alert the meteorologist to the occurrence of specified time-critical events; perform automated analysis and plotting of meteorological data; and provide for overlay, zoom, coordinate conversion to permit overlay graphics, and alphanumeric message composition and editing; and disseminate workstation products to other users within the National Airspace System.

To optimize the operational effectiveness of the Center Weather Service Unit for monitoring, interpretation, "nowcasting," and dissemination of hazardous aviation weather information, the meteorologist will be provided with a state-of-the-art automated workstation. This will enable the meteorologist to perform his tasks more efficiently, giving him the means to respond rapidly to National Airspace System requests, to validate weather products, and to concentrate on determining and supplying information and warnings about the actual (confirmed) or probable presence of hazardous weather areas.

A Central Weather Processor at the Central Flow Control Facility will have access to a complete weather data base covering the entire U.S. This will be used for the coordination of weather information with the flow control function.

Next Generation Weather Radar

The purpose of the Next Generation Weather Radar Program is to develop and procure a Doppler weather radar that will meet the weather detection needs of the Federal Aviation Administration, National Weather Service, U.S. Air Force Air Weather Service, the Naval Oceanography Command. It will also provide weather information to other government and private organizations. In order to accomplish this program, a NEXRAD Joint System Program Office (JSPO) was established. This office is funded and staffed by NWS, FAA, and U.S. Air Force (USAF).

The program is following an OMB Circular A-109 acquisition approach consisting of four phases. These are:

1. System Definition Phase
2. Validation Phase
3. Limited Production Phase
4. Full Production Phase

Three contractors participated in the system definition phase which resulted in a preliminary system design. Contracts have been awarded to two contractors for the validation phase. The validation phase will include software development, evaluation of high risk technical areas, and fabrication and test of a prototype radar system. At the conclusion of the validation phase, a contract will be awarded to one contractor for production.

The FAA requires radar detection of hazardous weather conditions in the en route, terminal, and FSS environments. The jointly operated network will provide the FAA with the required en route coverage and will also meet the needs of NWS, USAF, and U.S. Navy.

The following network weather radar products will be available to the FAA:

1. High Altitude Layer Reflectivity Map (18,000 ft. and above)
2. Low Altitude Layer Reflectivity Map (surface - 18,000 ft.)
3. High Altitude Layer Turbulence Map (18,000 ft. and above)
4. Middle Altitude Layer Turbulence Map (12,000 - 18,000 ft.)
5. Low Altitude Layer Turbulence Map (surface to 12,000 ft.)
6. Hail Information
7. Mesocyclone data
8. Echo Tops Map (altitudes selectable)
9. Storm Track Map from Storm Tracking Algorithm
10. Low Altitude Wind Shear (not included in validation phase)
11. Horizontal Wind Profile
12. Icing/Freezing Level (not included in validation phase)

National Airspace Data Interchange Network

National Airspace Data Interchange Network implementation, which will be accomplished in phases, will replace present outmoded switching systems with current state-of-the-art data switching technology to provide efficient and cost effective services for the new, near-term National Airspace Systems.

Phase II of this system will provide for further expansion of the interfacility communications network to accommodate weather information and future NAS requirements/systems such as the Advanced Automation System, Automated En Route Air Traffic Control, and Integrated Flow Management. This system will provide for all long haul communications and ARINC/airline interfaces. Implementation of this network will eliminate the AFTN switch and Service B circuits.

The initial phases of National Airspace Data Interchange Network (NADIN 1 and NADIN 1A) are designed to provide a common data network to support a number of ATC users who had separate networks for their message oriented services. In addition to switching messages, the initial network also performs specialized services such as error detection and correction, code, format and speed conversions, and storing and journaling of certain classes of traffic. There are other groups of users coming into service (e.g., Central Weather Processor and Weather Message Switching Center Replacement) who need accommodation in the network but have more stringent requirements (throughput and response times) than can be efficiently met by a message switched system. Packet switching will provide the requisite response times and reliability needed to handle these new services.

The NADIN II Packet Data Switch (PDS), as a major National Interfacility Communications System (NICS), will provide efficient means for data transmission through modern packet switching technology. In addition, NADIN II will provide network support services for implementation of message broadcast and journaling to a limited number of its subscribers. The communications line processing modules will interface the various subscriber lines that are connected to a typical NADIN II Packet Mode. These modules will accommodate various network access protocol implementation requirements. The various users such as airline dispatch offices, Automated Flight Service Stations, international air traffic control and military operators will interface with Area Control Facilities for weather products through NADIN II Switch via National Interfacility Communications Circuits.

Mode S Data Link

Mode S is a cooperative surveillance and communication system to support Air Traffic Control and provide other data link services such as weather products directly to the cockpit. This system uses ground-based interrogators and airborne transponders. Ground-to-air and air-to-ground data link communications is integral with the surveillance interrogations and replies. In the Mode S system, each aircraft is assigned a unique address code. Using this code, interrogations and the integral data link communications can be directed to a particular aircraft and replies unambiguously identified. Interference is minimized because a sensor limits its Mode S interrogations to targets of interest, and proper timing of interrogations permits replies from closely spaced aircraft to be received without mutual interference.

The airborne equipment necessary to support the planned data link applications includes a Mode S transponder with Comm A, B, C, and D message format capability and a data link terminal which includes a processor for decoding uplink messages and encoding downlink messages, an input device (i.e., keyboard), and one or more output devices (e.g., electronic display, printer, etc.). Maximum flexibility will be permitted in the aircraft avionics so that users can select from the wide variety of data link input and output techniques appropriate to the data link services they desire at an affordable cost.

The objective of the Mode S data link, in combination with a ground communications network, is to provide the pilot with direct access to ground data bases for flight advisory services. The initial Mode S data link services will provide benefits to the users by providing pilot access to useful weather information and benefit to the FAA by reducing ground personnel workload. Data link services will be developed with the entire aviation community considered. Services will be developed to meet the needs of the single engine general aviation users as well as air carriers.

The introduction of air-ground data link services will evolve over a period of years. It will start with an early mixture of a limited number of weather advisory services available to both the general aviation and air carrier users. These will be followed by enhanced weather services currently being defined.

The weather products under consideration for implementation by the FAA include:

- Terminal Forecasts
- Surface Observations
- Winds Aloft Forecasts
- Hazardous Weather Advisories
- Pilot Reports
- Radar Summary
- Radar Graphics

An effort is currently underway at the FAA Technical Center to develop the facilities to evaluate this message coding using various data link services. This facility will ultimately provide interface software for the Mode S sensor, terminal and en route ATC computers, the National Airspace Data Interchange Network ground communications test facility, the Flight Service Data Processing System, the Central Weather Processor, Automated Weather Observing Systems and other sources and destinations of data link messages. The FAA has contracted for the initial purchase of 137 Mode S sensors with the option to acquire another 60 units.

Weather Communications Processor (WCP)

The Weather Communications Processor will function as a communications node which will handle Mode S data link flight advisory messages (i.e. weather or other flight related messages). It will receive, translate and route the following to service computers such as the Flight Service Data Processing System and the Central Weather Processor: (1) pilot requests for flight advisory products and information on hazardous weather areas, and (2) pilot reports. It will also receive, translate and route the following to the appropriate Mode S sensor for delivery to the aircraft: (1) ground requests for flight advisory data and (2) pilot requested data such as airport Terminal and Area forecasts, surface weather observation data, winds aloft and radar summaries.

RESEARCH ACTIVITIES

The FAA, National Oceanic and Atmospheric Administration and National Aeronautics and Space Administration have established programs to improve winds aloft prediction; programs to detect wind shear and other hazardous weather phenomena; and programs for developing capabilities to measure runway friction to determine slippery conditions due to icing. Another effort in the area of evaluating runway conditions is being conducted by the FAA and the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL). These research and development activities are discussed in the following paragraphs.

Terminal Doppler Weather Radar

Terminal Doppler Weather Radar systems will be developed and deployed at major airports which experience a high incidence of severe weather. To ensure the detection and timely warning of low-altitude wind shears, such as microbursts/downbursts, and thunderstorms gust fronts, these radars will require high update rates, automated hazard identification, sophisticated clutter suppression, and proper siting and scanning strategies.

The FAA has established a Doppler weather radar facility near Memphis International Airport to support the NEXRAD program and investigate the application of Doppler weather radar to the airport environment. These efforts concentrate on siting/scanning strategies, detection and processing algorithms, automatic warning generation, and ATC interfaces. During 1986, the Doppler weather radar facility will be moved to Huntsville, AL to participate in the Microburst Severe Thunderstorm (MIST) experiment sponsored by the National Science Foundation. Doppler weather radar technology has matured to the stage where FAA is formulating implementation strategies upon which production of Terminal Doppler Weather Radar can be based.

Measurement of Winds and Temperatures Aloft

The Profiler being developed by NOAA will provide frequently updated upper air measurements of wind speed and direction, temperature and humidity. The NWS's Automated Aircraft Reporting System, using an Aircraft to Satellite Data Relay capability, will provide an enhanced upper air winds information data base. Real-time meteorological data will be transmitted by aircraft equipped with Inertial Navigation Systems to a satellite, for relay to a ground facility. NASA and NOAA have some other satellite-based wind measuring systems under consideration that use laser technology and visible infrared radiometry. These systems are in an experimental stage at present and further research will be needed to evaluate the feasibility of their operational use. The FAA's Mode S could also support down linking of winds and temperature information from appropriately equipped aircraft.

Program for Regional Observing and Forecasting Services

The Program for Regional Observing and Forecasting Services will address the short period local area weather forecasting problem by bringing together in one system real-time data sources, sophisticated computational processing, interactive display and short-term forecasting routines. The real-time data sources include satellite, radar (including Doppler), automated regional surface observations, and synoptic scale data.

Extensive real-time computing power is required to test the potential of various forecasting algorithms, and to interactively display the results. This capacity has been implemented within the Program for Regional Observing and Forecasting Services.

Wind Shear Program

Since the early 1970's, the Federal Aviation Administration has conducted a continuing program to investigate wind shear. The currently operational Low Level Wind Shear Alert System, being deployed at 110 airports, resulted from early wind shear program activities. The primary thrust of the now-developing Terminal Doppler Weather Radar program is wind shear protection for the airport environment. Research programs sponsored by other Federal agencies, industry, and the academic sector have contributed significantly to what is currently known about the wind shear phenomenon. Advisory Circulars, training films, and wind shear models for training and research simulators were developed and distributed throughout the aviation community.

FAA is developing an integrated wind shear program plan which is scheduled for release in early 1986. This plan will maintain a continuous focus on the educational, meteorological, technological and operational aspects of low-altitude wind shear hazards.

Additionally, development programs have been initiated that include: enhancements to the Low Level Wind Shear Alert System, development of an authoritative training aid on wind shear, and investigation of airborne wind shear detection systems.

National Aircraft Icing Program

The Departments of Commerce and Defense, FAA, and the National Aeronautics and Space Administration have activities which directly support aviation operations, and certain activities of the National Science Foundation are also related. The purpose of the charter of National Aircraft Icing Program Council

(NAIPC) is to define a joint program for the coordination of the aircraft icing activities of those agencies that should meet their common operational requirements as well as the unique requirements of individual agencies. A coordinated program which reflects the interdependencies among each agency's activities and between each system component should minimize overall costs as well as increase the effectiveness of the program. This multiagency program will function best if policy guidance and oversight is maintained by a high-level interagency council.

Aircraft Icing Research

The purpose of the Aircraft Icing Program is to develop and document a current technology base for regulatory actions to refine standards and advisory materials related to icing conditions. This research should ensure that the technology base exists to fully support safe, timely, and cost-effective compliance with aviation safety regulations.

Specific program objectives are:

1. Expand the existing supercooled cloud data base to include the total characterization of the aircraft icing environment

2. Develop data and documentation for establishing certification criteria and test procedures for icing protection concepts

3. Provide technical support to FAA certification authorities.

Measurement of Runway Conditions

The FAA and NASA are jointly developing means to measure runway friction under icy conditions. These activities will help the FAA in establishing the aircraft/runway icing criteria. The FAA and the U.S. Army Cold Regions Research and Engineering Laboratory are evaluating means to detect and measure the thicknesses of ice, snow, slush and water, and methods of rapidly removing the contaminants on runway surfaces. This project will help improve the airport operators efforts in keeping airports open in adverse winter conditions.

National Stormscale Operational and Research Meteorology Program

The purpose of the national STORM program is to improve basic mesoscale weather services. This includes: 1) the development of mesoscale numerical modeling capability to provide a fundamental understanding of small-scale weather activities; 2) the experimental field deployment to develop the capability to observe, analyze, forecast, and disseminate small-scale weather information; and 3) the implementation of optimum new generation, high technology operational systems necessary to meet service users small-scale support requirements.

The STORM Program sponsored by the National Academy of Sciences Panel on Mesoscale Programs will have an Interagency STORM Project Office established in NOAA. The research and development phase of STORM will involve, along with modeling facilities, a STORM-Central field experiment in 1987, followed by additional efforts in the Eastern and Western U.S. Interagency research planning and interagency operational planning teams will be created in the near future to plan and implement the STORM-Central project. Team participants will be provided by NOAA, NASA, DoD, NSF, Department of Energy, and the FAA. The Panel will continue to guide the STORM program including the planning of additional phases of the national program.

GEM Program (Generalized Equivalent Markov)

The purpose of the GEM program is to develop a statistical technique for predicting the probability distribution of all surface weather elements hour by hour, using only the current local surface weather conditions as predictors.

This effort was initiated by the NWS in 1981 and has been supported by the FAA since 1983. Currently, the technique is being tested and results will be published by the end of 1985. The program is then to be continued for another year, with a final report published by the end of 1986.

1995 AVIATION WEATHER SYSTEM ARCHITECTURE

The system consists of five types of integrated facilities: 1) National Aviation Weather Processing Facilities including the NADIN Switch, Aviation Weather Processor, Weather Message Switching Center Replacement, and the Consolidated NOTAM System; 2) Area Control Facilities; 3) Central Flow Control Facility; 4) Automated Flight Service Stations; and 5) Air Traffic Control Towers. An overall configuration of the Aviation Weather System hierarchy is shown in Figure 5-1.

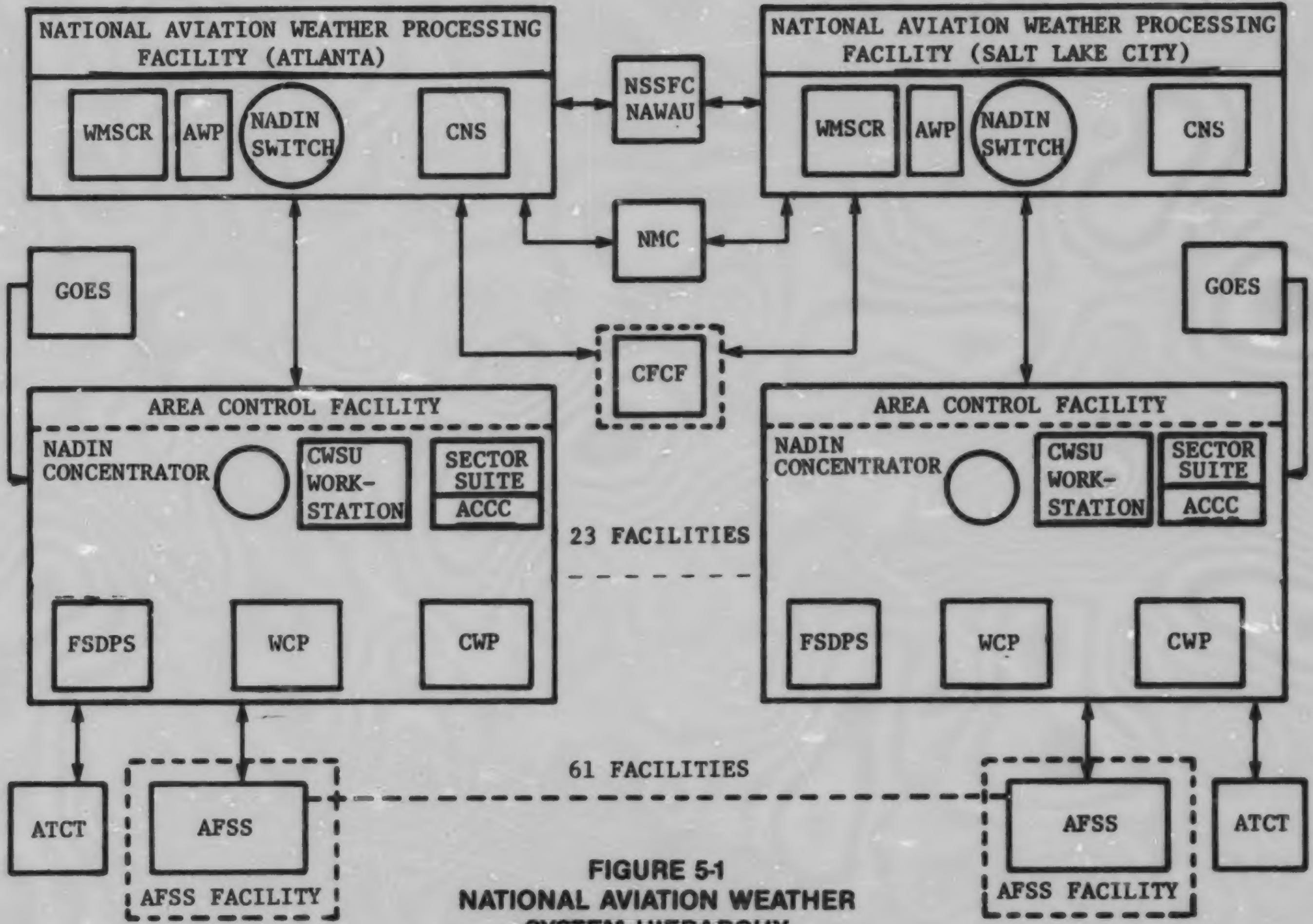
NATIONAL AVIATION WEATHER PROCESSING FACILITY (ATLANTA)
WMSCR
AWP
NADIN SWITCH
CNS
NSSFC NAWAU
NATIONAL AVIATION WEATHER PROCESSING FACILITY (SALT LAKE CITY)
WMSCR
AWP
NADIN SWITCH
CNS
NMC
GOES
GOES
CFCF
AREA CONTROL FACILITY
NADIN CONCENTRATOR
CWSU WORK-STATION
SECTOR SUITE
ACCC
FSDPS
WCP
CWP
23 FACILITIES
AREA CONTROL FACILITY
NADIN CONCENTRATOR
CWSU WORK-STATION
SECTOR SUITE
ACCC
FSDPS
WCP
CWP
ATCT
AFSS
AFSS FACILITY
61 FACILITIES
AFSS
AFSS FACILITY
ATCT

FIGURE 5-1
NATIONAL AVIATION WEATHER
SYSTEM HIERARCHY

This figure depicts the physical links between the five types of facilities. A detailed description of each facility is presented in the following subsections. Figure 5-2 shows the architecture of the 1995 Aviation Weather System.

At the national level, there will be two National Aviation Weather Processing Facilities, one located at Atlanta and the other located at Salt Lake City. Each of these facilities will house the Weather Message Switching Center Replacement, Aviation Weather Processor, Consolidated NOTAM System (CNS) and National Airspace Data Interchange Network Switch. All of the graphic and alphanumeric weather products generated at the National Meteorological Center and other National Weather Service facilities are sent to the weather processing facilities where they are stored, edited, reformatted, and disseminated to other FAA facilities in support of the National Airspace System.

The 23 Area Control Facilities are linked to the two National Aviation Weather Processing Facilities through The National Airspace Data Interchange Network Switch. In each Area Control Facility, the Central Weather Processor will receive Next Generation Weather Radar and other radar data through dedicated interfaces, mosaic these data into a data base covering the entire control area, receive alphanumeric and graphic weather data from the Weather Message Switching Center Replacement system, and combine all information to prepare weather products for dissemination to other systems and the meteorologists located at the Center Weather Service Unit workstation. The Central Weather Processor will also be connected to the Air Traffic Control system computers supplying it with the real-time weather information.

In the Area Control Facilities, weather information processing will also be provided by Flight Service Data Processing System. The role of this processor in the Aviation Weather System will be to process the weather data necessary to drive the Automated Flight Service Stations. There will be various enhancement packages implemented in the future that will facilitate the pilot's ability to have direct access to the weather information, via Direct User Access Terminals. The Voice Response System will automatically generate voice messages of meteorological information pertinent to aviation that could be accessed by pilots by telephone.

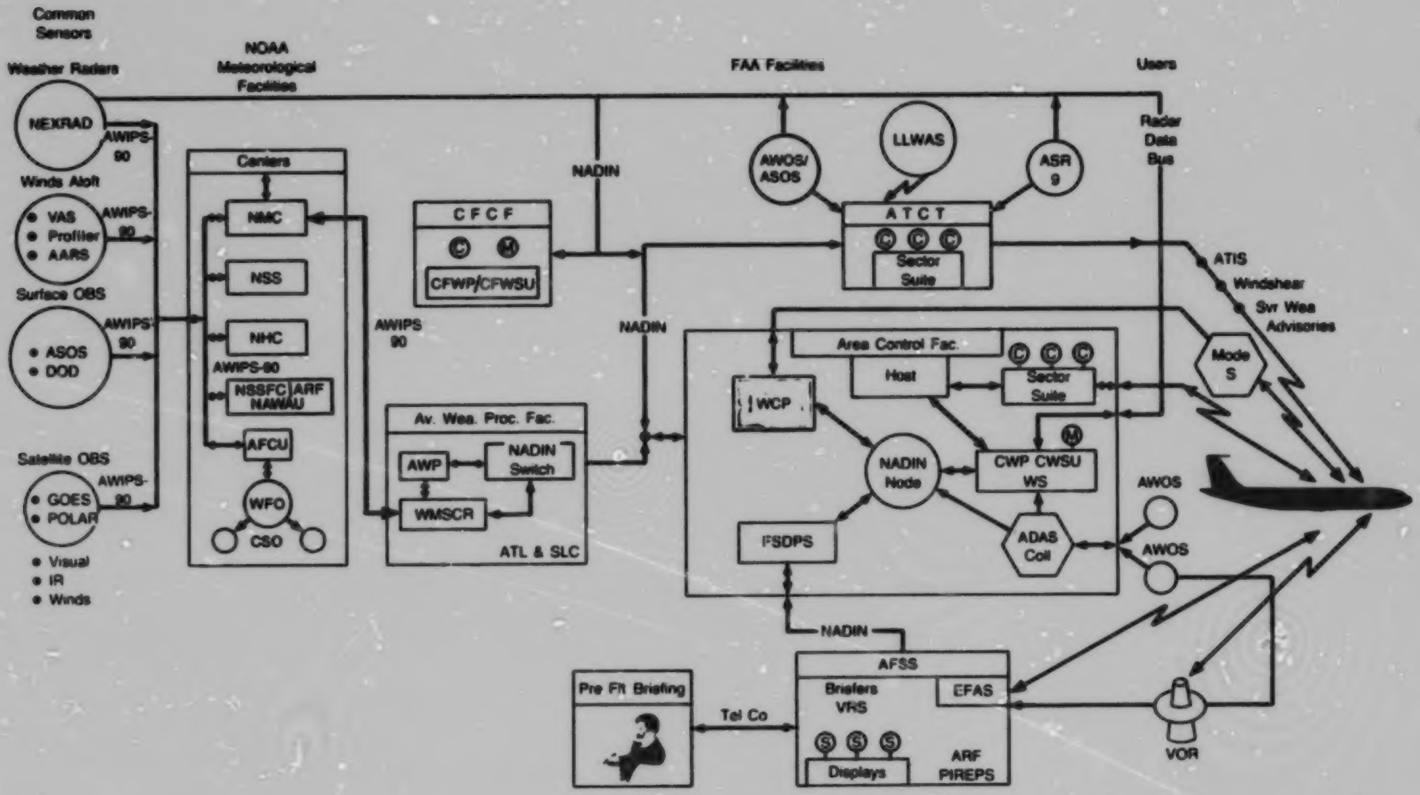
Common Sensors
Weather Radars
NEXRAD
AWIPS-90
Winds Aloft
VAS
Profiler
AARS
AWIPS-90
Surface OBS
ASOS
DOD
AWIPS-90
Satellite OBS
GOES
POLAR
AWIPS-90
Visual
IR
Winds
NOAA Meteorological Facilities
Centers
NMC
NSS
NHC
AWIPS-90
NSSFC NAWAU
ARF
AFCU
WFO
CSO
AWIPS 90
FAA Facilities
NADIN
CFCF
CFWP/CFWSU
Av. Wea. Proc. Fac.
AWP
NADIN Switch
WMSCR
ATL & SLC
NADIN
AWOS/ASOS
LLWAS
ASR 9
ATCT
Sector Suite
Users
Radar Data Bus
ATIS
Windshear
Svr Wea Advisories
Area Control Fac.
Host
Sector Suite
WCP
NADIN Node
CWP CWSU WS
FSDPS
ADAS Coll
Mode S
AWOS
AWOS
NADIN
AFSS
Briefers VRS
EFAS
Displays
ARF PIREPS
Pre Flt Briefing
Tel Co
VOR

FIGURE 5-2
1995 AVIATION WEATHER SYSTEM ARCHITECTURE

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The Mode S Data Link Processing function will be provided by a Weather Communications Processor (WCP). The AWOS Data Acquisition System will poll the control area's individual surface weather observing systems for data on scheduled basis, as well as perform other functions pertaining to storing and forwarding of the data.

In addition to the aviation weather subsystems located in the Area Control Facilities, a Central Flow Weather Processor will also be located in the Central Flow Control Facility. This Central Flow Weather Processor will be used for coordination of weather information with the flow control function.

In the U.S. there will be-61 Automated Flight Service Stations. Through their displays, the specialists will have access to alphanumeric and graphic weather data.

Pertinent weather data to the Air Traffic Control Tower will be supplied by the Central Weather Processor located in the Area Control Facility via the Area Control Computer Complex (ACCC) interfacing with that tower. In addition to the weather data received from the Area Control Facility, the towers will have direct interface to weather radar systems and sensors. For instance, an ASR-9 (Terminal Doppler Weather Radar in future), Low Level Wind Shear Alert System, and the Automated Weather Observing System will provide weather data to the towers.

National Aviation Weather Processing Facility

Figure 5-3 depicts the logical flow of data in the National Aviation Weather Processing Facility and its interface with other major facilities of the Aviation Weather System. As is shown in Figure 5-3 and mentioned earlier, this facility is comprised of four subsystems: the Aviation Weather Processor, Weather Message Switching Center Replacement, Consolidated NOTAM System, and National Airspace Data Interchange Network Switch.

The Aviation Weather Processor is intended to house, maintain, and process a national weather data base for use by Automated Flight Service Stations. This processor will receive weather data from the Weather Message Switching Center Replacement located at the same facility. It will edit, expand, process, and store these weather data and subsequently distribute them to the Flight Service Data Processing Systems located in the Area Control Facilities. Weather update information, in turn, will be received from the Flight Service Data Processing

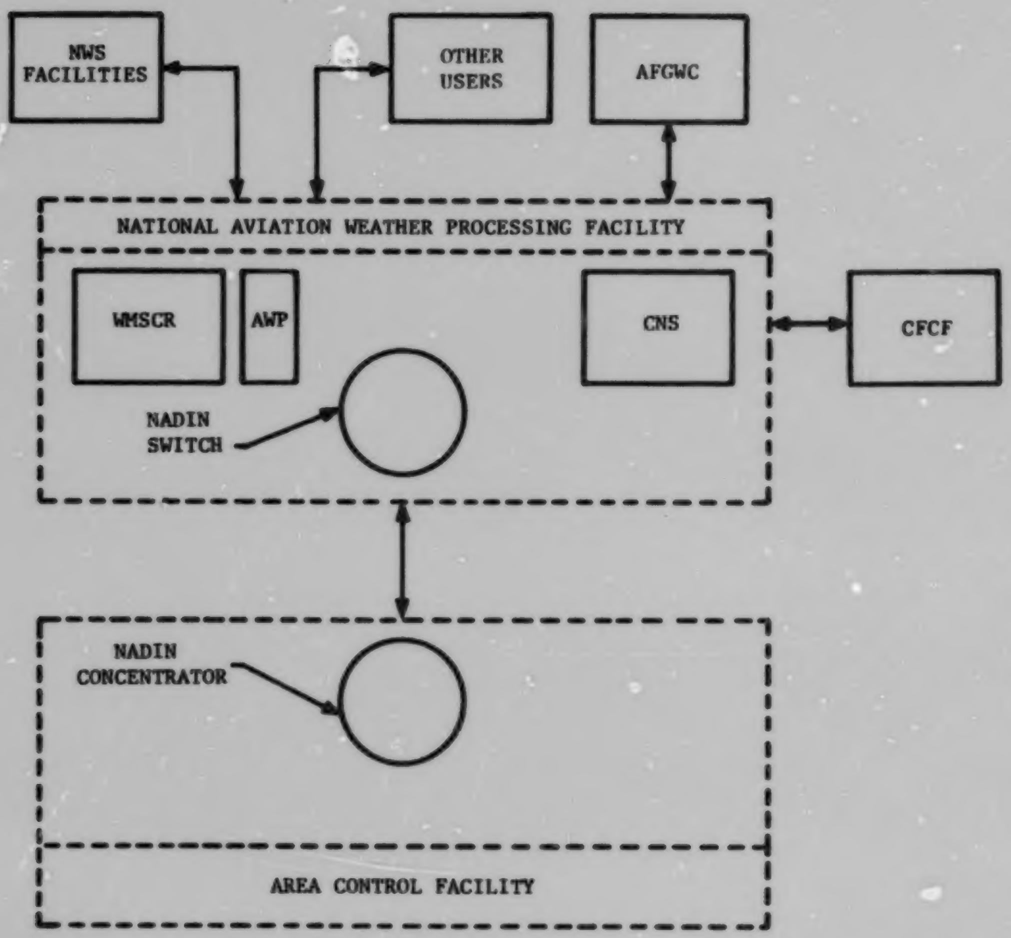
NWS FACILITIES
OTHER USERS
AFGWC
NATIONAL AVIATION WEATHER PROCESSING FACILITY
WMSCR
AWP
CNS
CFCF
NADIN SWITCH
NADIN CONCENTRATOR
AREA CONTROL FACILITY

FIGURE 5-3
WEATHER INFORMATION FLOW
NATIONAL AVIATION WEATHER PROCESSING FACILITY

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Systems and sent to the Weather Message Switching Center Replacement for dissemination to other users and systems. In addition to weather processing, the Aviation Weather Processor will receive, store, and distribute NOTAM messages appropriate to Automated Flight Service Station operations. The Weather Message Switching Center Replacement will collect the pertinent meteorological data including the Aviation Route Forecast products from the National Meteorological Center and other National Weather Service facilities, and disseminate them to other processors in the Aviation Weather System. Other users and organizations involved in the dissemination of aviation weather products, will be the recipients of these data from the Weather Message Switching Center Replacement. The Consolidated NOTAM System processor will provide the NOTAM formatting and editing capabilities for National Airspace System, and will also serve as the centralized NOTAM data bases. The National Airspace Data Interchange Network includes computers that will act as the switch to schedule the transfer of data across the national network to various systems and users. This network will also handle the unscheduled weather alerts and messages. Weather data at the national level will be provided to the Central Flow Control Facility for the flow control function.

Area Control Facility

Figure 5-4 depicts the logical connection between the various systems in an Area Control Facility environment, along with interfaces with other facilities. As shown in the figure, the main processing systems in the Area Control Facility are the Central Weather Processor, Flight Service Data Processing System, a Weather Communications Processor and the AWOS Data Acquisition System. The Central Weather Processor will accept, contour, and create a mosaic of weather radar data from multiple radars (i.e., NEXRAD, ASR-9 or Terminal Doppler Weather Radar) into an image for the area controlled by the Area Control Facility, and disseminate it, or its subset, to various users. It will also maintain a data base containing the weather information applicable to that facility, as required by various systems and users, and distribute them automatically on demand. This data base will include: weather radar data; alphanumeric weather information such as observations, forecasts and warnings; and weather graphics. Finally, the Central Weather Processor will support an interactive, meteorologist's automated workstation (Center Weather Service Unit workstation) that will facilitate the forecasting process for the on-duty meteorologist.

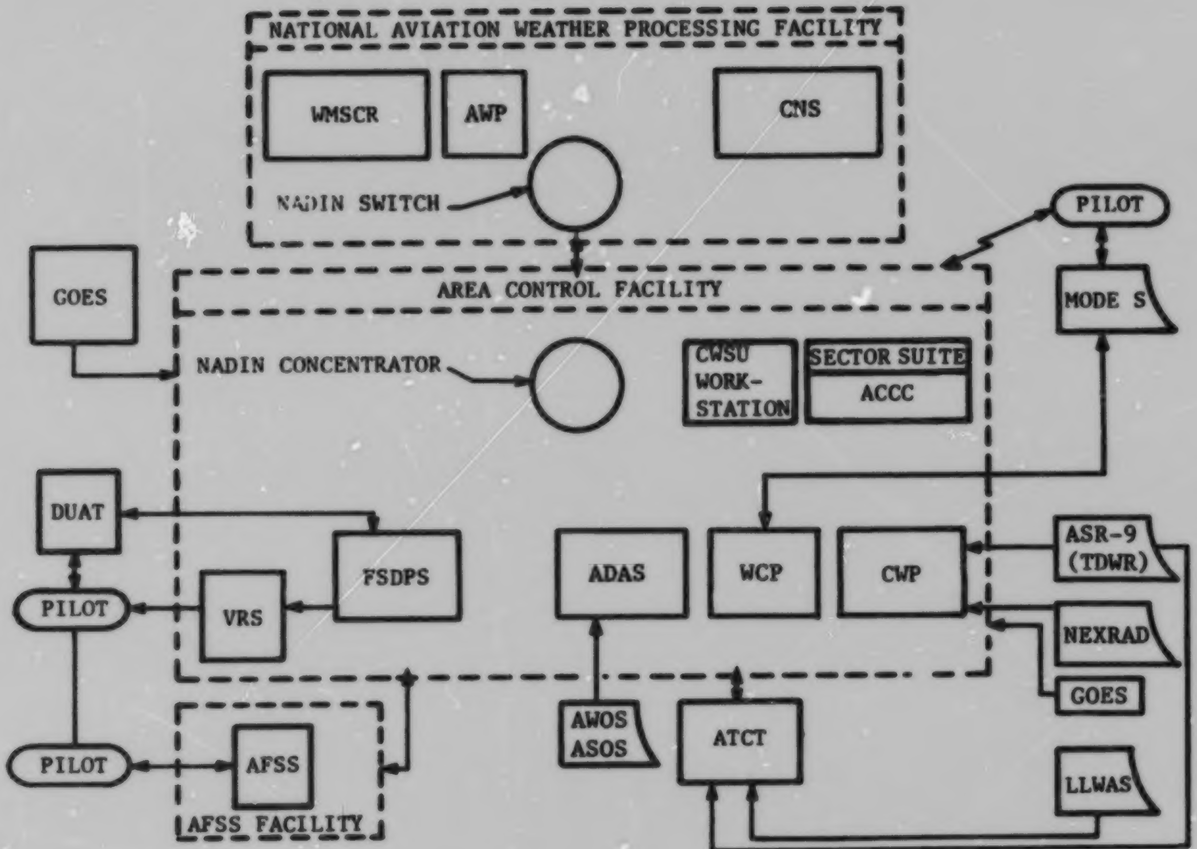

NATIONAL AVIATION WEATHER PROCESSING FACILITY
WMSCR
AWP
CNS
NADIN SWITCH
PILOT
GOES
AREA CONTROL FACILITY
MODE S
NADIN CONCENTRATOR
CWSU WORK-STATION
SECTOR SUITE
ACCC
DUAT
FSDPS
ADAS
WCP
CWP
ASR-9 (TDWR)
PILOT
VRS
NEXRAD
GOES
AWOS ASOS
ATCT
PILOT
AFSS
LLWAS
AFSS FACILITY

FIGURE 5-4
WEATHER INFORMATION FLOW
AREA CONTROL FACILITY

The Area Control Computer Complex shall accept and process weather data from the Central Weather Processor, ATC radars, and controllers. The Central Weather Processor will be the primary source for weather data. The Central Weather Processor will provide graphic weather products and alphanumeric weather products. A backup source for real-time graphic weather data will be the ATC radars. The ATC radar weather data will be used when the Central Weather Processor is unavailable or when radars interfaced with the Central Weather Processor do not provide sufficient coverage. The Area Control Computer Complex will store these alphanumeric weather products and distribute them to Sector Suites on request by the controllers. The ACCC will also accept aeronautical and meteorological data change messages and PIREP messages from the controllers, send these messages to the Central Weather Processor, and amend the appropriate data base files.

The Flight Service Data Processing System will be used to provide the Flight Service Station operation with the automated data processing capabilities. These capabilities include the flight plan processing and dissemination. Also, this system will receive the weather information from both the Aviation Weather Processor and Central Weather Processor, and distribute it to the Automated Flight Service Stations, Direct User Access Terminals, and other system users via the Voice Response System. The weather information would be processed after being received from the Aviation Weather Processor by each Flight Service Data Processing System through a National Airspace Data Interchange Network concentrator. The Flight Service Data Processing System will also receive surface observation data from the AWOS Data Acquisition System. All alphanumeric and graphic weather information will be transferred via the National Airspace Data Interchange Network in the future Aviation Weather System.

Mode S data link will provide a direct interface between the Area Control Facility and pilots through the Weather Communications Processor for up/down linking of weather information to the Central Weather Processor and Flight Service Data Processing System. Certain high activity terminals within the Area Control Facility may be equipped with an ASR-9, and in the future with either a Terminal Doppler Weather Radar or both. The weather data from both radar systems will be provided directly to the Central Weather Processor located in the facility. The Automated Weather Observing Systems will be installed at airports and will be connected to an AWOS Data Acquisition System. The surface observations collected from various individual systems in the area of control will be sent by this system through the National Airspace Data Interchange Network to the National Aviation Weather Processing Facility, and to the other Processors in the Area Control Facility.

Automated Flight Service Station System

The Automated Flight Service Station system provides interactive workstations for the personnel at the Automated Flight Service Stations. They will be connected directly to The Flight Service Data Processing System through FAA owned telecommunications and leased telephone circuits to receive both alphanumeric and graphic weather information. In turn, input messages will be entered through the Automated Flight Service Stations and sent back to the Flight Service Data Processing System for further processing. These messages include NOTAMs, flight plans, weather data, PIREPs, and requests for stored data. Figure 5-5 depicts the local flow of information in this facility and its interface with other facilities.

EVOLUTION OF AVIATION WEATHER SYSTEM CAPABILITIES

The various elements of the future Aviation Weather System pertaining to surface observations, data processing, forecasting, communications, and hazardous weather detection capabilities, will be developed and installed by 1995. Some of these systems will be implemented in phases to provide a smooth transition from the current weather system to the system of 1995. Figure 5-6 illustrates how various categories of users will access the Aviation Weather System for weather information. The mode of communication and the user interface with individual processing capabilities within the Aviation Weather System are also highlighted. Individual System development activities in near or mid/long term and the various subsystems which will evolve into a well integrated weather system design are illustrated in Figures 5-7 to 5-16. Figure 5-7 presents the evolution plan for the various weather systems. Figures 5-8 through 5-16 illustrate the evolution of individual subsystems.

The FAA has approved and published a National Airspace System Level I Design document in October 1984 and a System Requirements Specification document in March 1985 which constitute the requirements baseline of the NAS. The Level I Design defines the basic NAS elements, subelements and subsystems, and their inter-relationships. It presents a qualitative, high-level system definition which identifies the allocation of functions to specific subsystems and subelements, provides a description of the interfaces, and outlines the data flow across each interface. These documents are two of several designed to direct the FAA and its support and engineering contractors in their collective efforts to accomplish a major upgrade of the National Airspace System. The Level I Design will also serve as the basis for the development of the NAS Specification now in process. The Specification will provide the system topology; identify the quantity, location, and connectivity of subsystems and facilities; performance requirements; and data and voice loading on each of the interfaces.

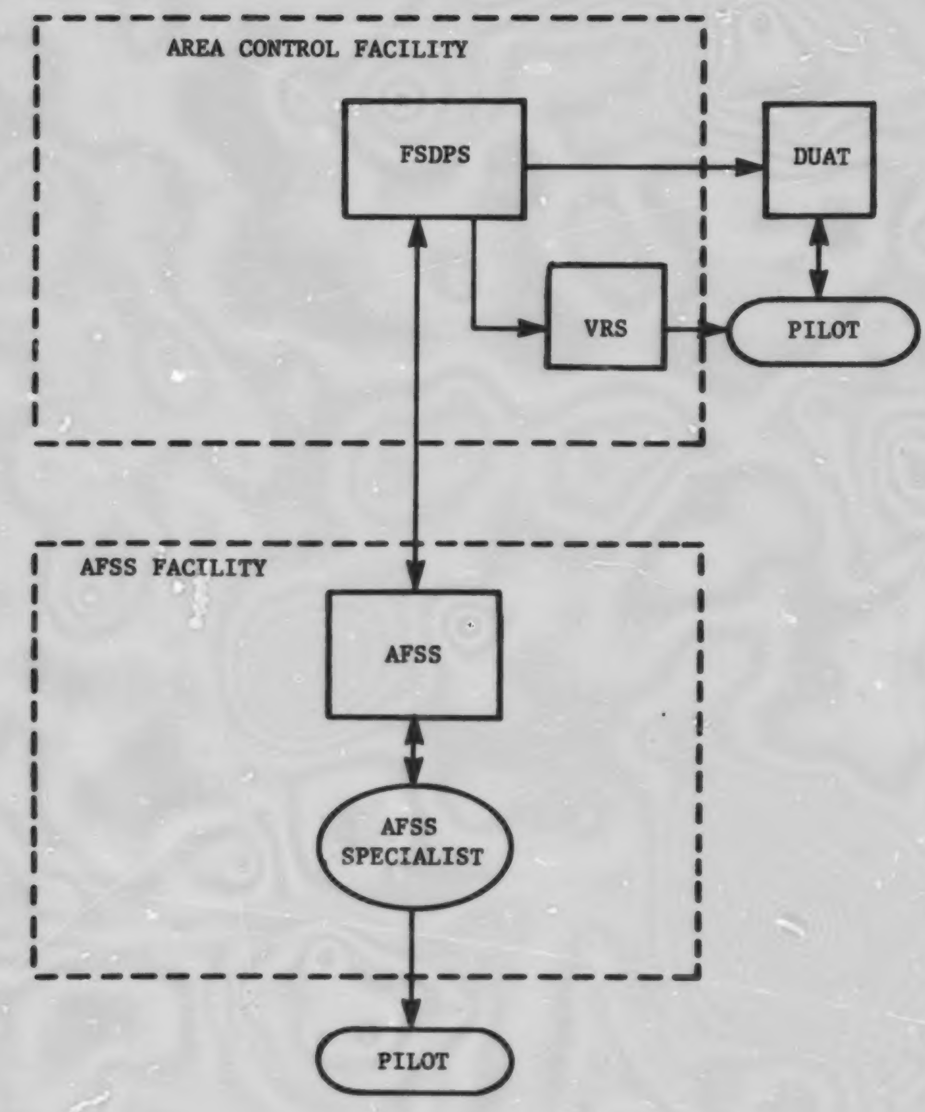
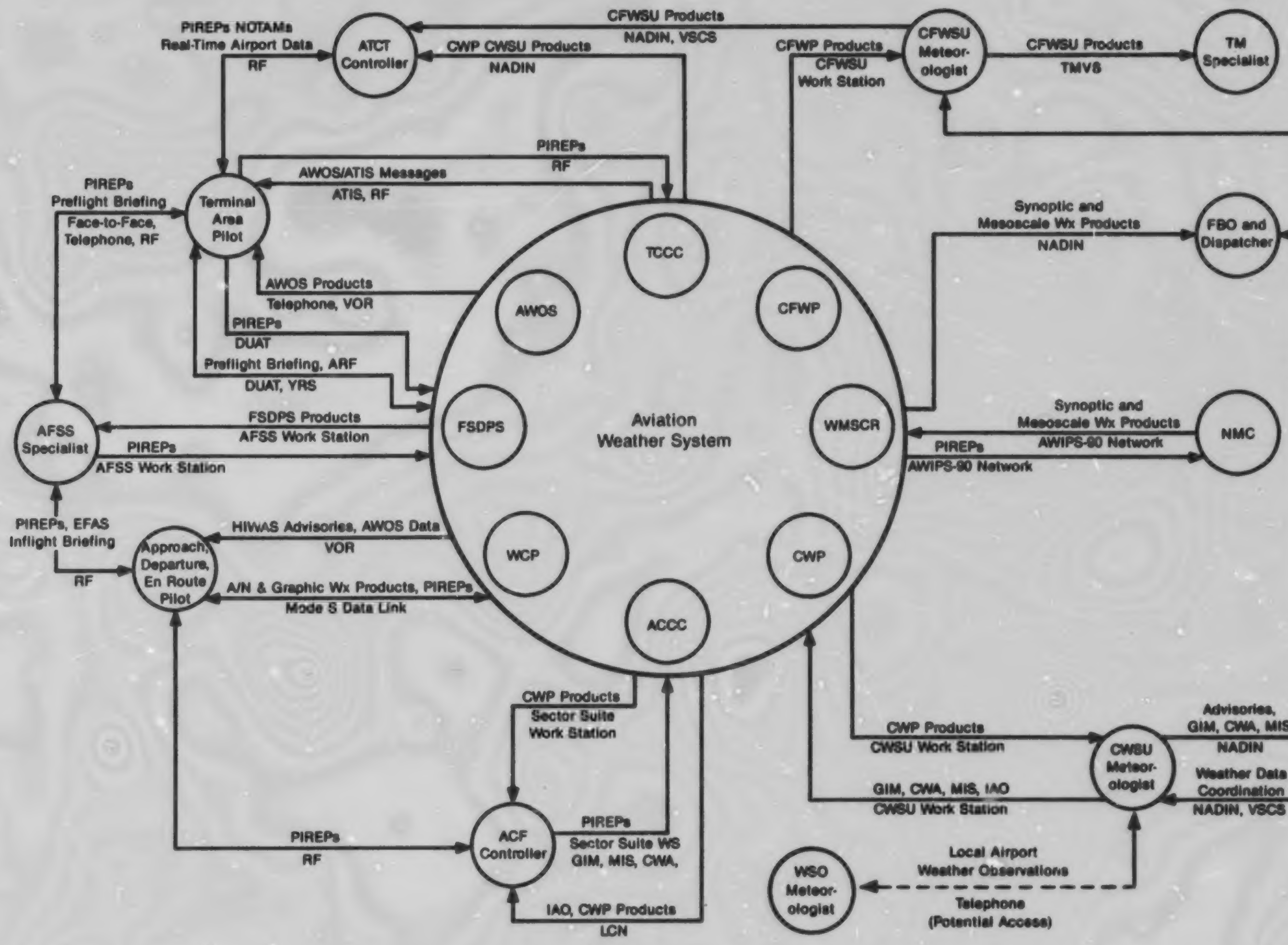

AREA CONTROL FACILITY
FSDPS
DUAT
VRS
PILOT
AFSS FACILITY
AFSS
AFSS SPECIALIST
PILOT

FIGURE 5-5
WEATHER INFORMATION FLOW
AUTOMATED FLIGHT SERVICE STATION

60



CFWSU Products
NADIN, VSCS
PIREPs NOTAMs
Real-Time Airport Data
RF
ATCT Controller
CWP CWSU Products
NADIN
CFWP Products
CFWSU Work Station
CFWSU Meteor-ologist
CFWSU Products
TMVS
TM Specialist
PIREPs
RF
AWOS/ATIS Messages
ATIS, RF
PIREPs
Preflight Briefing
Face-to-Face, Telephone, RF
Terminal Area Pilot
Synoptic and Mesoscale Wx Products
NADIN
FBO and Dispatcher
TCCC
AWOS Products
Telephone, VOR
AWOS
CFWP
PIREPs
DUAT
Preflight Briefing, ARF
DUAT, YRS
Aviation Weather System
FSDPS
WMSCR
Synoptic and Mesoscale Wx Products
AWIPS-90 Network
NMC
AFSS Specialist
FSDPS Products
AFSS Work Station
PIREPs
AFSS Work Station
PIREPs
AWIPS-90 Network
PIREPs, EFAS
Inflight Briefing
RF
HIWAS Advisories, AWOS Data
VOR
Approach, Departure, En Route Pilot
A/N & Graphic Wx Products, PIREPs
Mode S Data Link
WCP
CWP
ACCC
CWP Products
Sector Suite Work Station
CWP Products
CWSU Work Station
Advisories, GIM, CWA, MIS
NADIN
CWSU Meteor-ologist
GIM, CWA, MIS, IAO
CWSU Work Station
Weather Data Coordination
NADIN, VSCS
PIREPs
RF
ACF Controller
PIREPs
Sector Suite WS
GIM, MIS, CWA,
IAO, CWP Products
LCN
WSO Meteor-ologist
Local Airport Weather Observations
Telephone (Potential Access)

FIGURE 5-6
USER ACCESS TO THE LONG-TERM AVIATION WEATHER SYSTEM

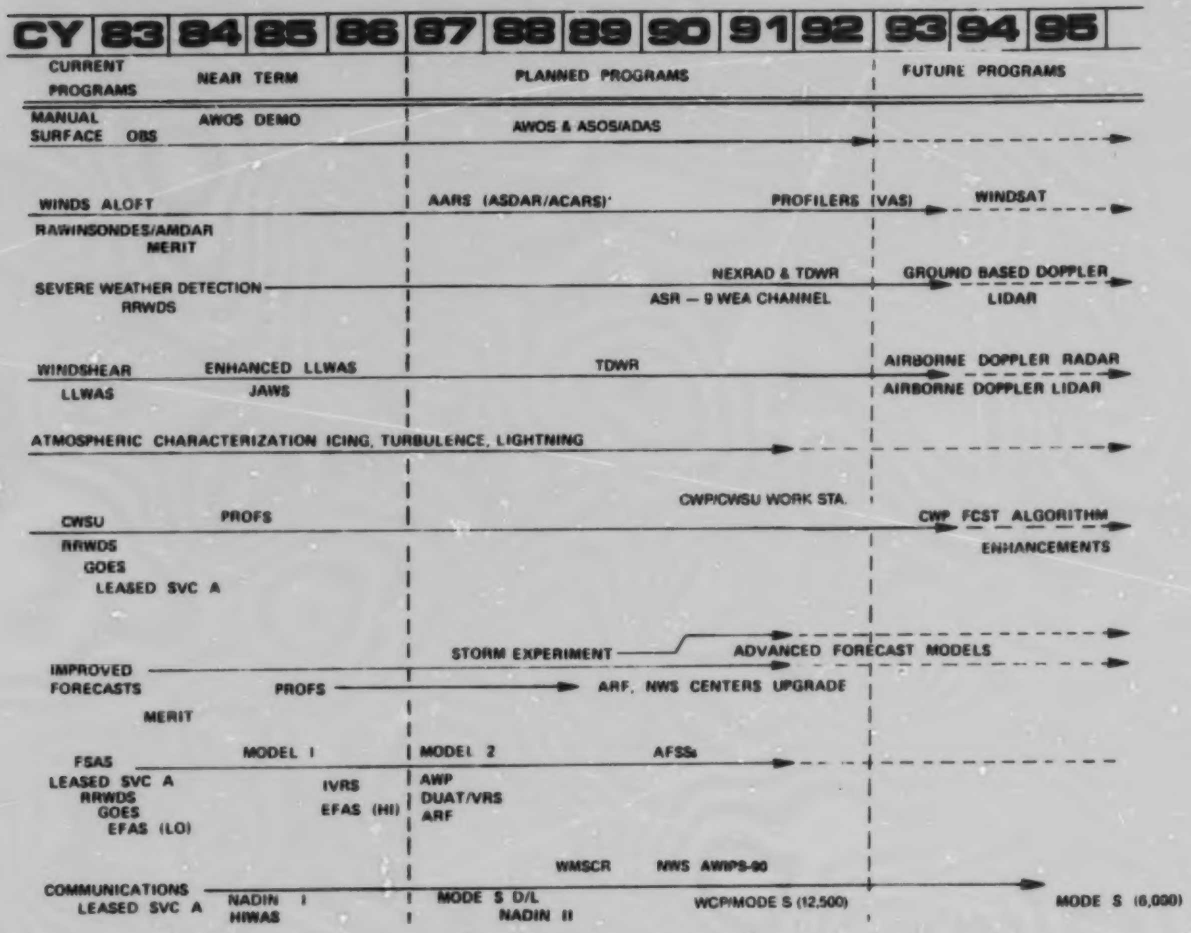
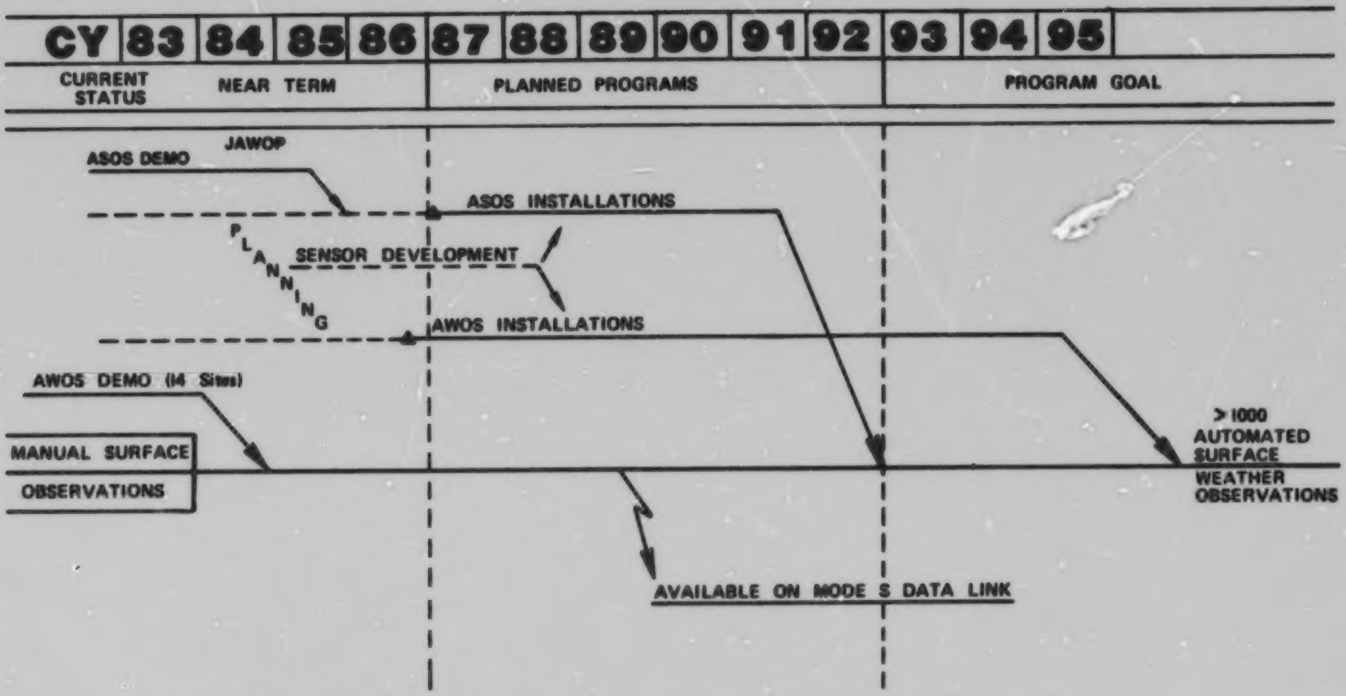

CY 83 84 85 86 87 88 89 90 91 92 93 94 95
CURRENT PROGRAMS
NEAR TERM
PLANNED PROGRAMS
FUTURE PROGRAMS
MANUAL SURFACE OBS
AWOS DEMO
AWOS & ASOS/ADAS
WINDS ALOFT
RAWINSONDES/AMDAR
MERIT
AARS (ASDAR/ACARS)
PROFILERS (VAS)
WINDSAT
SEVERE WEATHER DETECTION
RRWDS
NEXRAD & TDWR
ASR – 9 WEA CHANNEL
GROUND BASED DOPPLER LIDAR
WINDSHEAR
LLWAS
ENHANCED LLWAS
JAWS
TDWR
AIRBORNE DOPPLER RADAR
AIRBORNE DOPPLER LIDAR
ATMOSPHERIC CHARACTERIZATION ICING, TURBULENCE, LIGHTNING
CWSU
RRWDS
GOES
LEASED SVC A
PROFS
CWP/CWSU WORK STA.
CWP FCST ALGORITHM ENHANCEMENTS
IMPROVED FORECASTS
MERIT
STORM EXPERIMENT
ADVANCED FORECAST MODELS
PROFS
ARF, NWS CENTERS UPGRADE
FSAS
LEASED SVC A
RRWDS
GOES
EFAS (LO)
MODEL I
IVRS
EFAS (HI)
MODEL 2
AWP
DUAT/VRS
ARF
AFSSs
COMMUNICATIONS
LEASED SVC A
NADIN I
HIWAS
MODE S D/L
NADIN II
WMSCR
NWS AWIPS-90
WCP/MODE S (12,500)
MODE S (6,000)

FIGURE 5-7
EVOLUTION OF THE AVIATION WEATHER SYSTEM


CY
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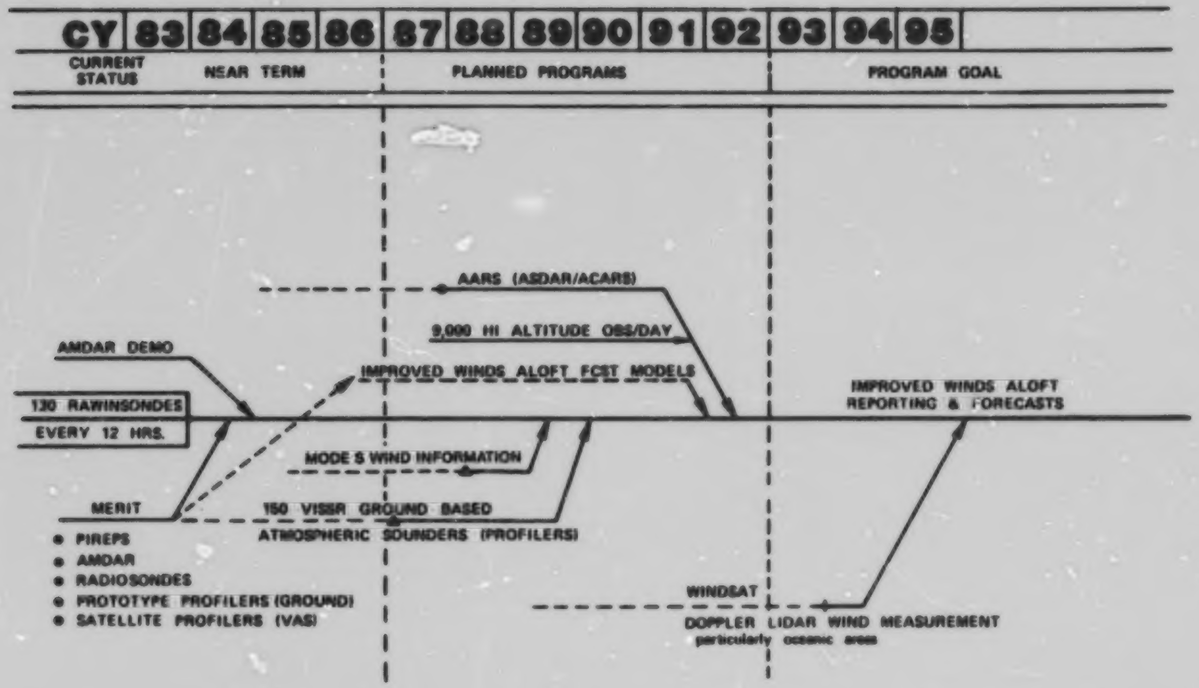
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
ASOS DEMO
JAWOP
ASOS INSTALLATIONS
PLANNING
SENSOR DEVELOPMENT
AWOS INSTALLATIONS
AWOS DEMO (14 Sites)
MANUAL SURFACE OBSERVATIONS
> 1000 AUTOMATED SURFACE WEATHER OBSERVATIONS
AVAILABLE ON MODE S DATA LINK

FAA AUTOMATED WEATHER OBSERVING SYSTEM (AWOS): WIND, TEMP, DEW POINT, PRESSURE (ALTIMETER SETTING), VISIBILITY, CLOUD HEIGHT

FIGURE 5-8
EVOLUTION OF SURFACE OBSERVING SYSTEMS


CY
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CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
AARS (ASDAR/ACARS)
9,000 HI ALTITUDE OBS/DAY
AMDAR DEMO
IMPROVED WINDS ALOFT FCST MODELS
IMPROVED WINDS ALOFT REPORTING & FORECASTS
130 RAWINSONDES
EVERY 12 HRS.
MODE S WIND INFORMATION
MERIT
150 VISSR GROUND BASED
ATMOSPHERIC SOUNDERS (PROFILERS)
• PIREPS
• AMDAR
• RADIOSONDES
• PROTOTYPE PROFILERS (GROUND)
• SATELLITE PROFILERS (VAS)
WINDSAT
DOPPLER LIDAR WIND MEASUREMENT
particularly oceanic areas

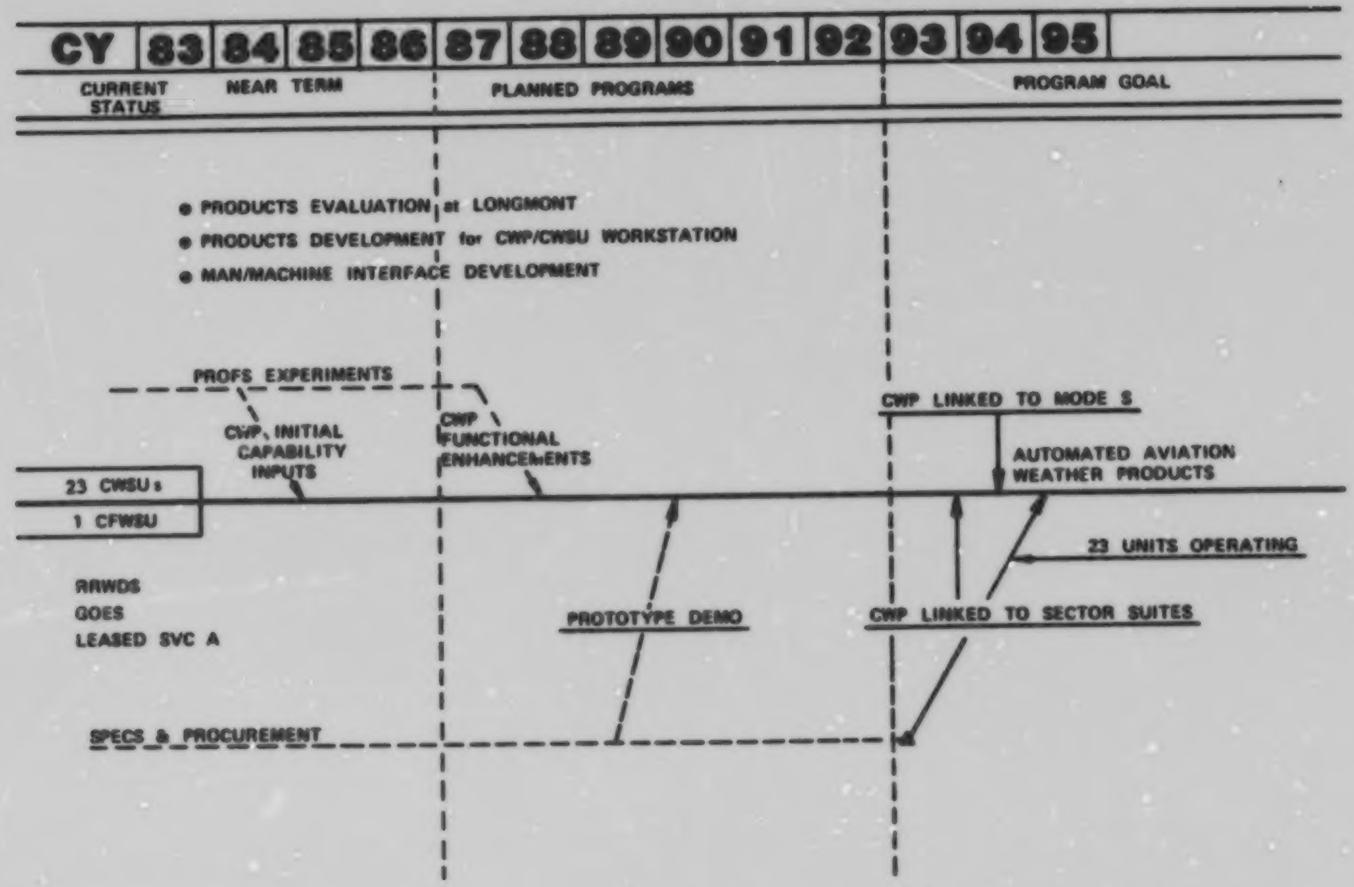
AMDAR: AIRCRAFT METEOROLOGICAL DATA RELAY -- VHF TO ARINC TO NMC/ AIRCARRIERS

ASDAR: AIRCRAFT TO SATELLITE DATA RELAY -- WIND & TEMP EVERY 7.5 MINS

ACARS: VHF ARINC COMMUNICATIONS ADDRESSING & REPORTING SYSTEM -- AUTO DISTRIBUTION

MERIT: MINIMUM ENERGY ROUTES USING INTERACTIVE TECHNIQUES

FIGURE 5-9
EVOLUTION OF IMPROVED WINDS ALOFT


CY
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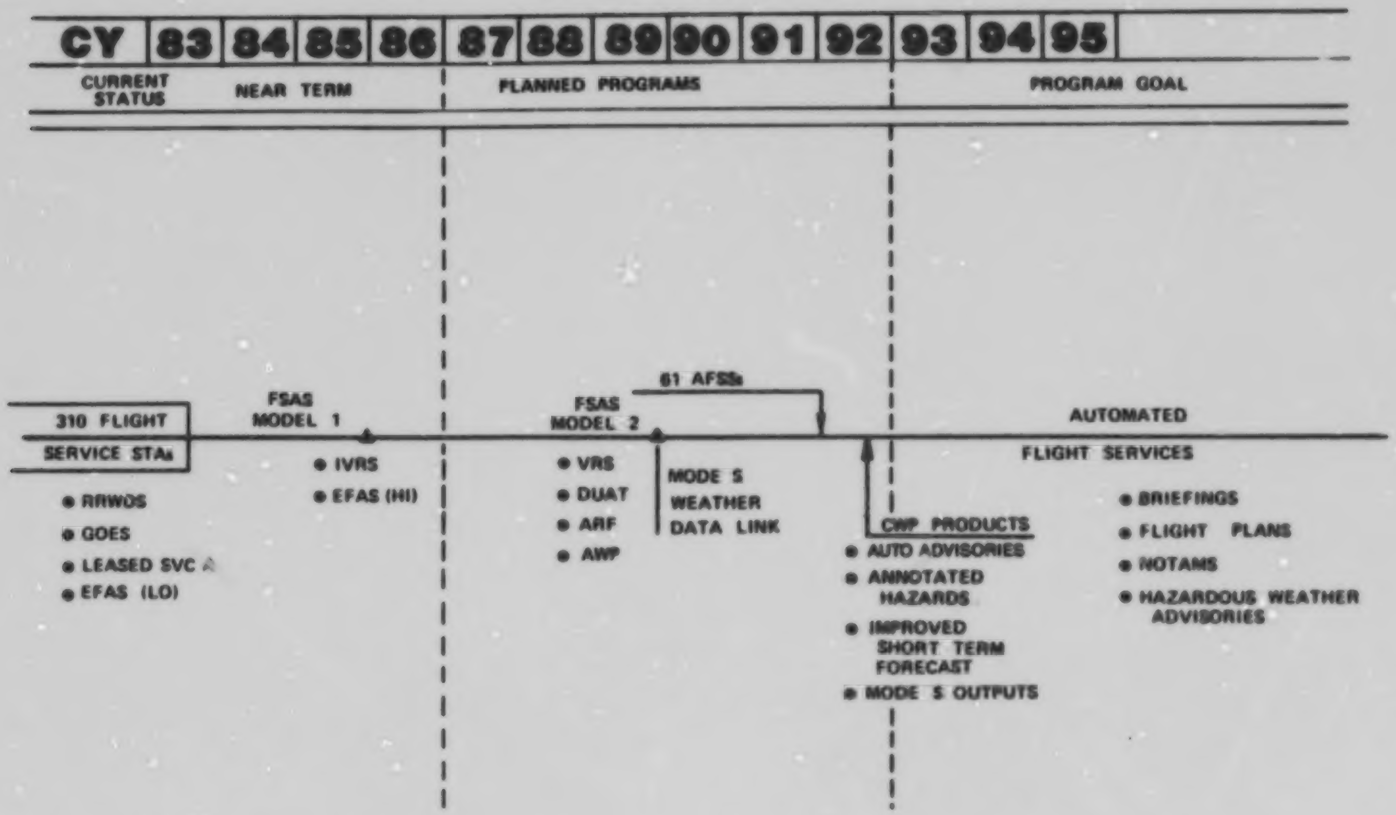
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
● PRODUCTS EVALUATION at LONGMONT
● PRODUCTS DEVELOPMENT for CWP/CWSU WORKSTATION
● MAN/MACHINE INTERFACE DEVELOPMENT
PROFS EXPERIMENTS
CWP, INITIAL CAPABILITY INPUTS
CWP FUNCTIONAL ENHANCEMENTS
CWP LINKED TO MODE S
AUTOMATED AVIATION WEATHER PRODUCTS
23 CWSU s
1 CFWSU
23 UNITS OPERATING
RRWDS
GOES
LEASED SVC A
PROTOTYPE DEMO
CWP LINKED TO SECTOR SUITES
SPECS & PROCUREMENT

FIGURE 5-10
EVOLUTION OF THE CENTER WEATHER SERVICE UNITS


CY
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CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
310 FLIGHT SERVICE STAs
FSAS MODEL 1
FSAS MODEL 2
61 AFSSs
AUTOMATED FLIGHT SERVICES
RRWDS
GOES
LEASED SVC A
EFAS (LO)
IVRS
EFAS (HI)
VRS
DUAT
ARF
AWP
MODE S WEATHER DATA LINK
CWP PRODUCTS
AUTO ADVISORIES
ANNOTATED HAZARDS
IMPROVED SHORT TERM FORECAST
MODE S OUTPUTS
BRIEFINGS
FLIGHT PLANS
NOTAMS
HAZARDOUS WEATHER ADVISORIES

FIGURE 5-11
EVOLUTION OF FLIGHT SERVICE STATION AUTOMATION

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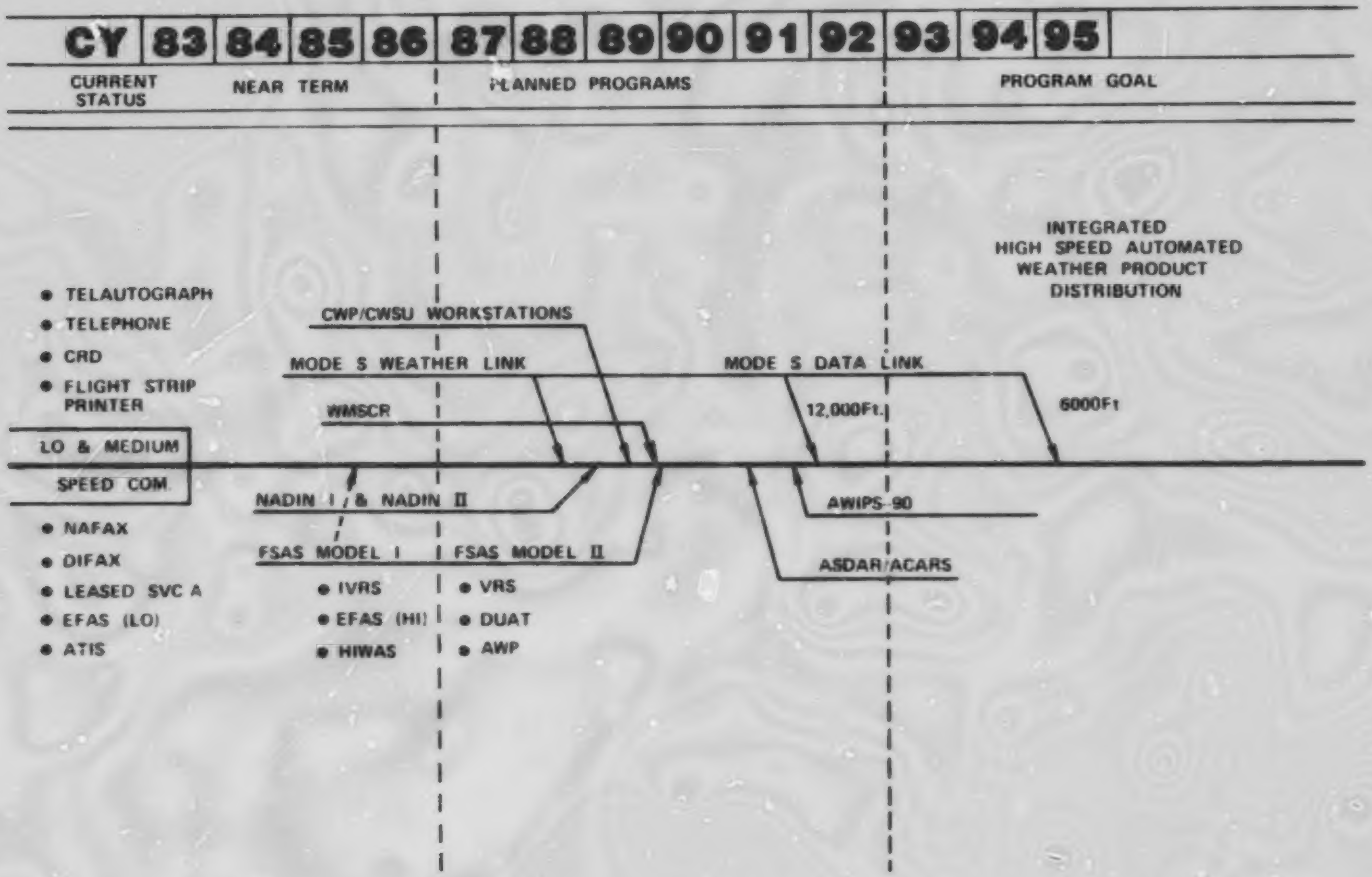
CY
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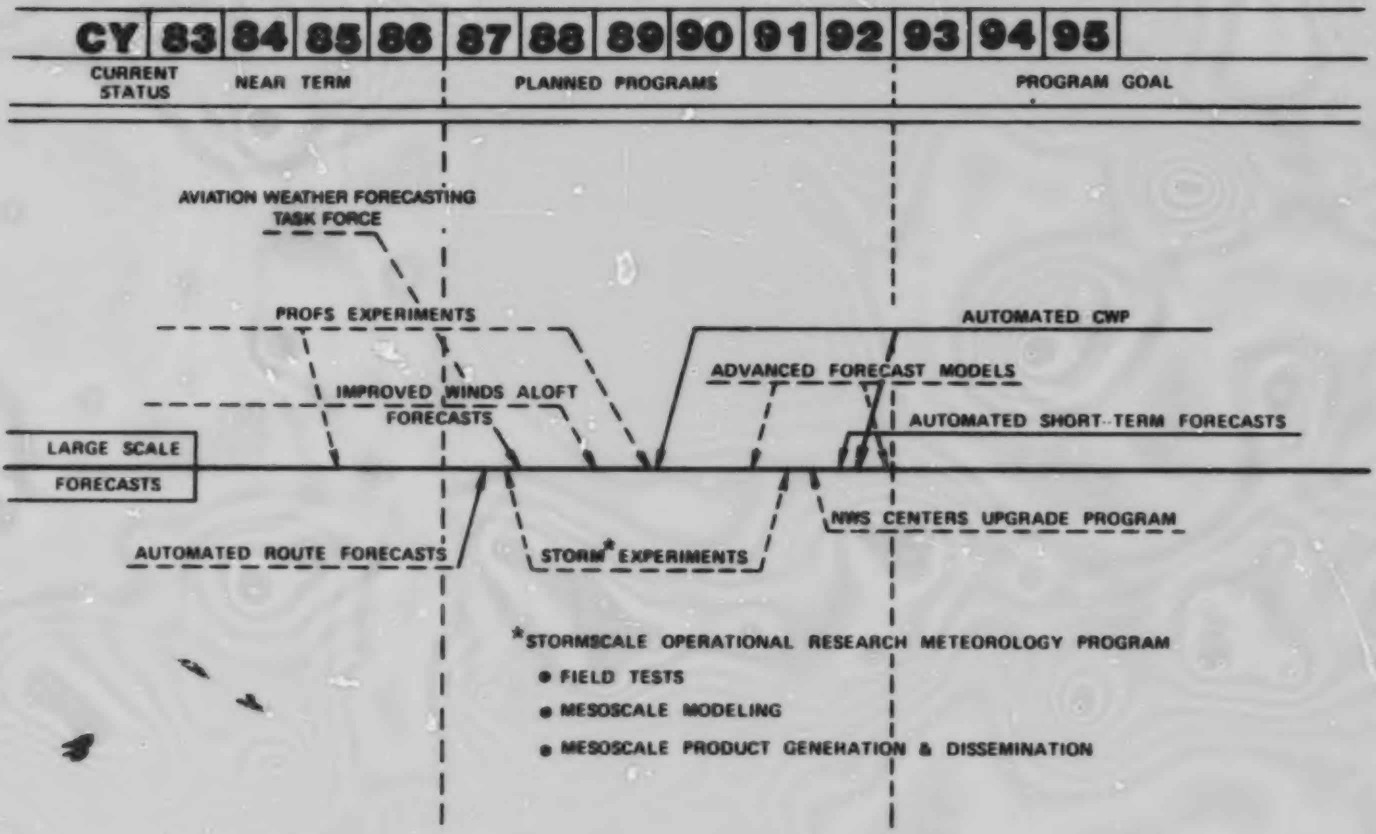
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
INTEGRATED HIGH SPEED AUTOMATED WEATHER PRODUCT DISTRIBUTION
● TELAUTOGRAPH
● TELEPHONE
● CRD
● FLIGHT STRIP PRINTER
CWP/CWSU WORKSTATIONS
MODE S WEATHER LINK
MODE S DATA LINK
12,000Ft.
6000Ft
WMSCR
LO & MEDIUM
SPEED COM
NADIN I & NADIN II
AWIPS-90
FSAS MODEL I
FSAS MODEL II
ASDAR/ACARS
● NAFAX
● DIFAX
● LEASED SVC A
● EFAS (LO)
● ATIS
● IVRS
● EFAS (HI)
● HIWAS
● VRS
● DUAT
● AWP

FIGURE 5-12
EVOLUTION OF WEATHER COMMUNICATIONS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CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
AVIATION WEATHER FORECASTING TASK FORCE
PROFS EXPERIMENTS
IMPROVED WINDS ALOFT FORECASTS
LARGE SCALE FORECASTS
AUTOMATED ROUTE FORECASTS
STORM* EXPERIMENTS
AUTOMATED CWP
ADVANCED FORECAST MODELS
AUTOMATED SHORT-TERM FORECASTS
NWS CENTERS UPGRADE PROGRAM

*STORMSCALE OPERATIONAL RESEARCH METEOROLOGY PROGRAM

- FIELD TESTS
- MESOSCALE MODELING
- MESOSCALE PRODUCT GENERATION & DISSEMINATION

FIGURE 5-13
EVOLUTION OF IMPROVED FORECASTS

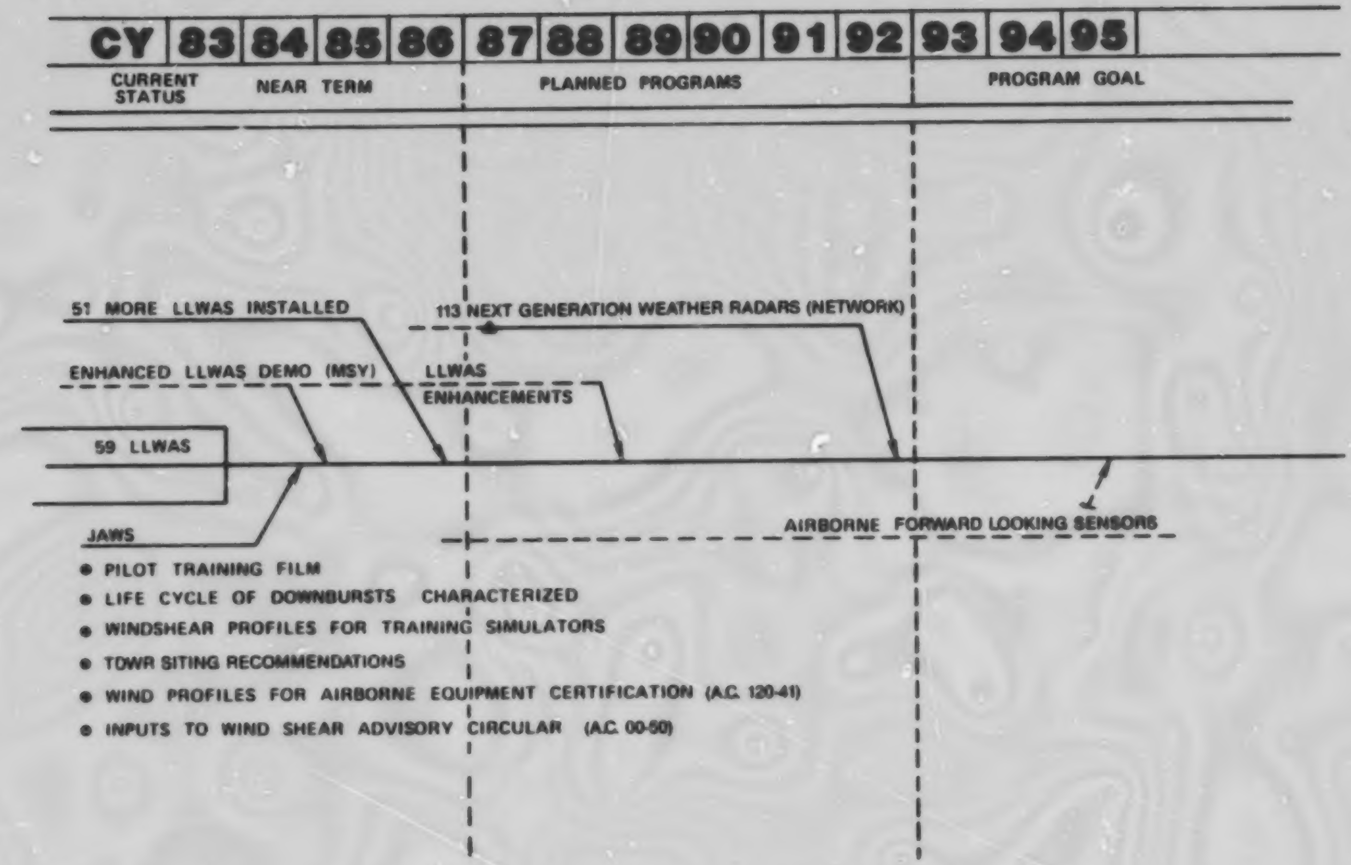
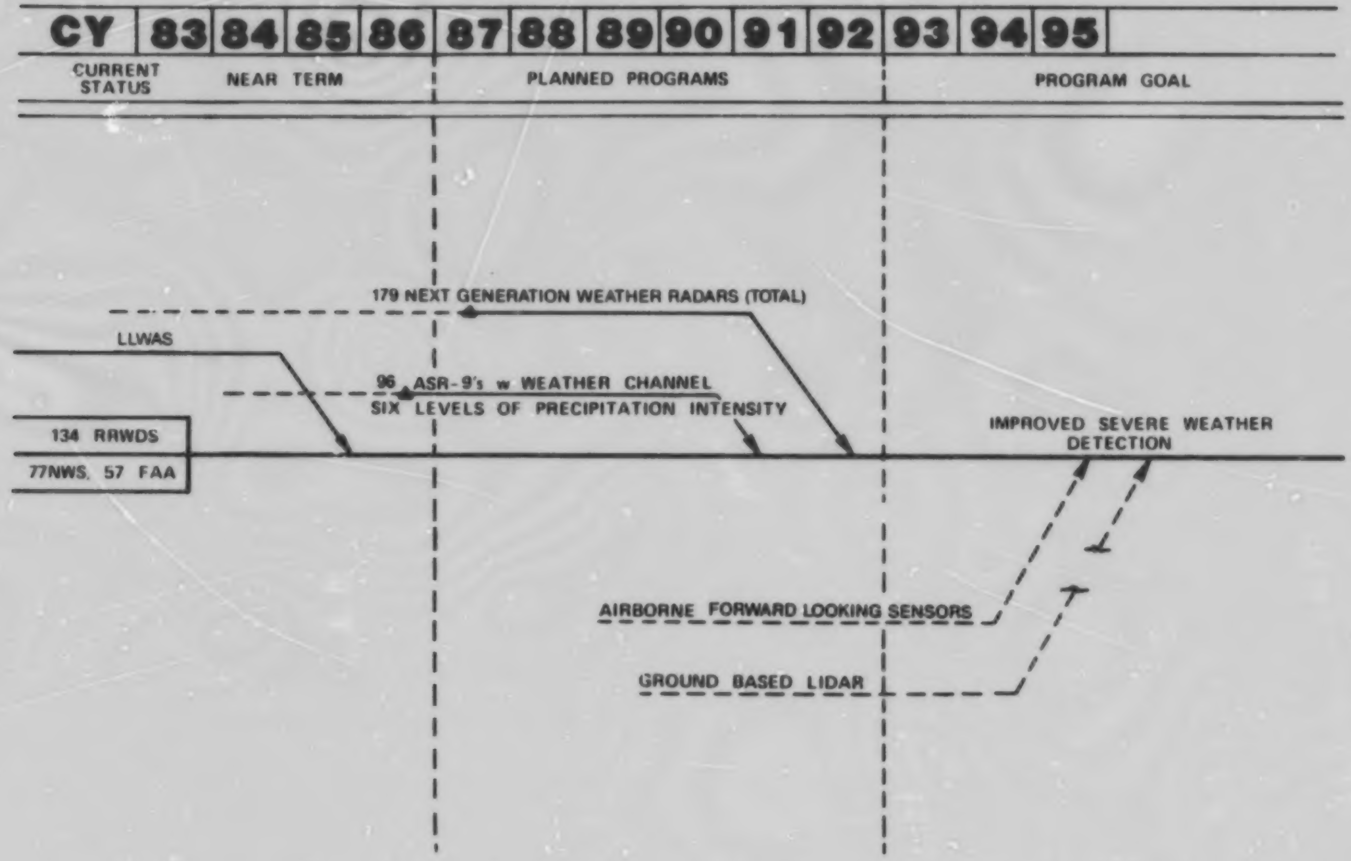

CY 83 84 85 86 87 88 89 90 91 92 93 94 95
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
51 MORE LLWAS INSTALLED
113 NEXT GENERATION WEATHER RADARS (NETWORK)
ENHANCED LLWAS DEMO (MSY)
LLWAS ENHANCEMENTS
59 LLWAS
AIRBORNE FORWARD LOOKING SENSORS
JAWS
• PILOT TRAINING FILM
• LIFE CYCLE OF DOWNBURSTS CHARACTERIZED
• WINDSHEAR PROFILES FOR TRAINING SIMULATORS
• TDWR SITING RECOMMENDATIONS
• WIND PROFILES FOR AIRBORNE EQUIPMENT CERTIFICATION (A.C. 120-41)
• INPUTS TO WIND SHEAR ADVISORY CIRCULAR (A.C. 00-50)

FIGURE 5-14
EVOLUTION OF WINDSHEAR DETECTION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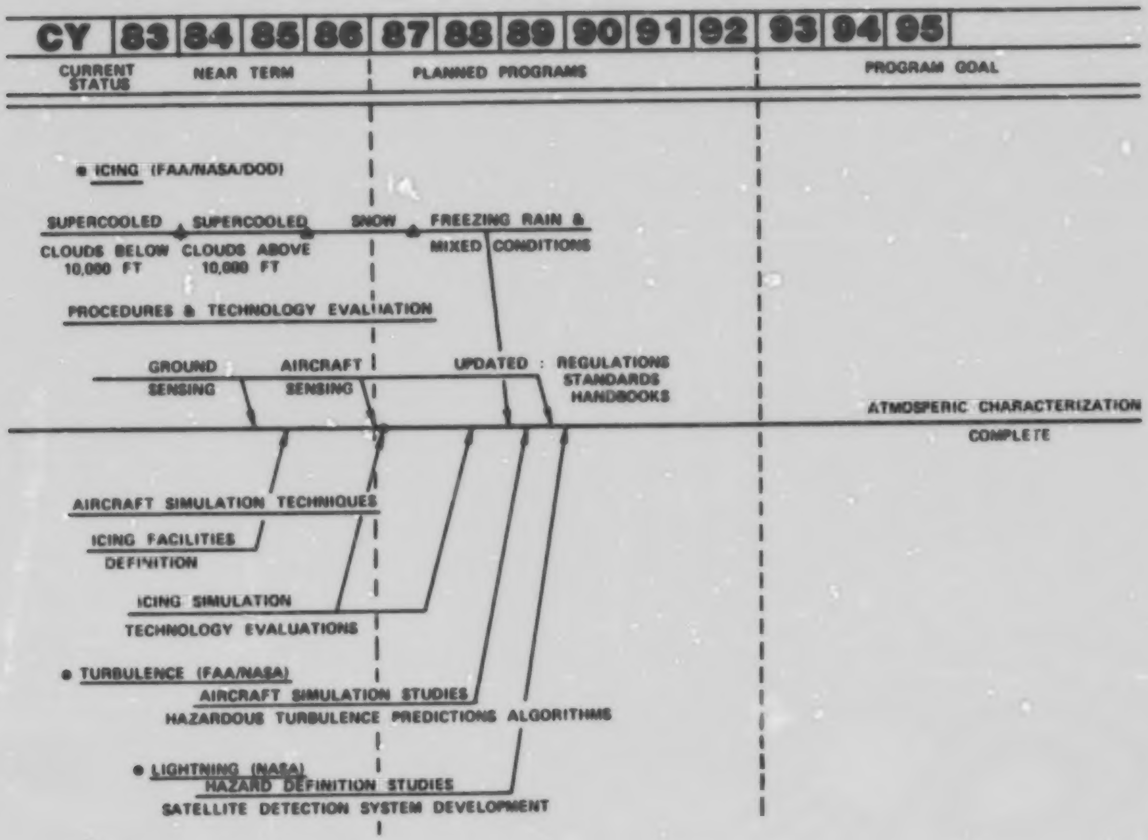
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
179 NEXT GENERATION WEATHER RADARS (TOTAL)
LLWAS
96 ASR-9's w WEATHER CHANNEL
SIX LEVELS OF PRECIPITATION INTENSITY
134 RRWDS
77NWS, 57 FAA
IMPROVED SEVERE WEATHER DETECTION
AIRBORNE FORWARD LOOKING SENSORS
GROUND BASED LIDAR

FIGURE 5-15
EVOLUTION OF SEVERE WEATHER DETECTION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95
CURRENT STATUS
NEAR TERM
PLANNED PROGRAMS
PROGRAM GOAL
• ICING (FAA/NASA/DOD)
SUPERCOOLED CLOUDS BELOW 10,000 FT
SUPERCOOLED CLOUDS ABOVE 10,000 FT
SNOW
FREEZING RAIN & MIXED CONDITIONS
PROCEDURES & TECHNOLOGY EVALUATION
GROUND SENSING
AIRCRAFT SENSING
UPDATED : REGULATIONS
STANDARDS
HANDBOOKS
ATMOSPERIC CHARACTERIZATION COMPLETE
AIRCRAFT SIMULATION TECHNIQUES
ICING FACILITIES DEFINITION
ICING SIMULATION TECHNOLOGY EVALUATIONS
• TURBULENCE (FAA/NASA)
AIRCRAFT SIMULATION STUDIES
HAZARDOUS TURBULENCE PREDICTIONS ALGORITHMS
• LIGHTNING (NASA)
HAZARD DEFINITION STUDIES
SATELLITE DETECTION SYSTEM DEVELOPMENT

FIGURE 5-16
EVOLUTION OF ATMOSPHERIC CHARACTERIZATION

6. FUTURE RESEARCH

A careful analysis of requirements and existing programs reveals that in order to interface various systems under development so as to evolve into an efficient Aviation Weather System architecture, major design work will need to be performed. The FAA has already initiated efforts to develop a well integrated future weather system design. However, there is a set of requirements that may not be met by an immediate application of existing technology and further research and development is needed. The areas that constitute the set of unmet requirements are discussed below.

- Accurate Descriptions of Storm Systems: Presently, detailed knowledge of storm systems is limited and there is a tendency to generally avoid penetration solely on the basis of precipitation intensity returns. There is a need to accurately describe mesoscale storm systems that would allow operational decisions as to the possibility of conducting flight operations in and around the storm system.

- Improved Winds Aloft Observations and Forecasts: Lack of spatial and temporal resolution of today's observed upper air data is reflected in the limitations in resolution and accuracy of the current wind and temperature forecast information. Upper air data observations need to be improved in order to provide an expanded data base capable of generating accurate wind and temperature information, both observed and forecast, with much improved resolution.

- Detection of Turbulence: There is a need to develop techniques to detect, in real-time, the presence of moderate to severe turbulence conditions.

- Definition of the Low and Middle Altitude Aircraft Icing Environment: Improvements are needed in real-time detecting, reporting, and forecasting of icing conditions. Methods of predicting surface runway and ground aircraft icing conditions are also needed.

- Airborne Detection of Wind Shear: There is a need to develop onboard instrumentation, techniques and displays for the provision of wind shear information to the pilot.

- **Detection and Forecasting of Microbursts**: There is a need to develop a Doppler weather radar for accurately detecting wind shear in terminal areas (or other systems to automatically detect low altitude hazardous weather phenomena such as microbursts through signature recognition algorithms). Alert messages need to be automatically disseminated to controllers and pilots.

7. FAA AVIATION WEATHER SYSTEM DEVELOPMENT PROGRAMS

A major challenge facing the Aviation Weather System development programs is to guide the evolution of the future system in an orderly manner without affecting the existing system operations. Adequate technological means are available for solving the diverse technical problems. However, the greater problem is how to apply these means to obtain maximum operational benefits.

The Aviation Weather System development has been structured into four program areas: Weather Data Processing and Distribution Enhancements, Weather Radar Improvements, Weather Observing Systems Automation, and Supporting Research Programs.

Weather Data Processing and Distribution Enhancements include the determination and development of the automated support needed by the Center Weather Service Unit and Central Flow Weather Service Unit meteorologists; improved communication of weather information; development of new or enhanced automated services for pilots, controllers, and Flight Service Station specialists; and improvements in weather products needed to maintain aviation safety.

Weather Radar Improvements consist of the joint development of a nationwide network of Doppler weather radars. These radars will provide an improved hazardous weather detection, identification and location capability, and will thus ensure more effective advisory service to pilots.

Weather Observing Systems Automation activities cover the overall development of surface weather observation systems, new and improved sensors, and will include support for heliports. By automating weather observation and collection methods, more frequent, real-time weather information will be obtained and distributed automatically.

The Supporting Research Programs are those designed to satisfy requirements that are not currently met by existing technologies. They provide for continuation of the state-of-the-art enhancements in each of the program areas, development of new sensors, improvements in weather forecasting techniques and models, and operational weather product development. Because of the nature of these programs, many government agencies are involved.

Specific FAA programs within each of these major areas are described in this section.

WEATHER DATA PROCESSING AND DISTRIBUTION ENHANCEMENT PROGRAMS

- Flight Service Automation System (p. 7-5)
- Central Weather Processor (p. 7-7)
- Interim Voice Response System (p. 7-9)
- Mode S/Data Link (p. 7-10)
- Weather Message Switching Center Replacement (p. 7-12)
- Weather Communications Processor (p. 7-13)
- National Data Interchange Network 2 (p. 7-15)

Project: Flight Service Automation System

Purpose: Develop an Automated Flight Service Station to replace the existing manual Flight Service Station operation. Implement Flight Service Data Processing Systems at all Area Control Facilities and establish 61 Automated Flight Service Stations. Full implementation will meet the projected increase in user demand, improve user access to weather information and Notices to Airmen, simplify flight plan filing, and also reduce the cost of individual services.

Approach: Automation will be developed and implemented in three steps: Model 1 (limited specialist automation), Model 2 (full specialist automation with limited direct user access capability), and Model 2 Enhancements (full direct user access capability). All of the Model 1 hardware has been procured by the prime contractor and hardware integration testing has been successfully completed. Model 1 software design and the software build test are completed, and the first field delivery of Model 1 system is scheduled for December 1985. Model 2 will be developed in discrete steps building on the base provided by the Model 1 design in order to reduce the risk involved in the development of Model 2.

Enhancements to Model 2 FSAS for enhanced direct user access capability will be provided through concept development, test, evaluation, and system specification. The approach will be to evaluate enhancement concepts and to specify the functional requirements as enhancement packages to be integrated into the Model 2 FSAS. Expected enhancement packages at this time include the following:

- Package 1 - Voice response system, self-briefing terminal access, and ground-to-air transmission of local area weather.
- Package 2 - Aviation route forecast, Center Weather Service Unit interface, flight plan filing and expanded VRS weather products, and development of interfaces for the Mode S data link system.
- Package 3 - Improved FSS specialist aids, additional meteorological products, and expanded direct user access terminal functions.
- Package 4 - Broadcast in-flight weather data via VHF omnirange, automatic direction finder flight service

automation system computation, new Central Flow Control Facility interface/functions, voice recognition for VRS, weather data transmission over VOR, and automated data base processing.

Products:

Model 1

13 Flight Service Data Processing Systems.

37 Automated Flight Service Stations equipped with automation position equipment.

Model 2

2 Aviation Weather Processors.

23 total Flight Service Data Processing Systems.

61 Automated Flight Service Stations.

Model 2 Enhancements

Enhancement hardware and/or software will be procured for use at all 61 Model 2 Automated Flight Service Stations.

Related Projects/Activities: Acquisition of Flight Service facilities - space for the 61 Automated Flight Service Stations will be acquired on a sponsor-provided, leased basis at selected airports in the United States and Puerto Rico.

Schedule:

- Model 1 Field Installation - commence December 1985
- Model 2 Field Installation - 1990

Project: Central Weather Processor

Purpose: To provide each Area Control Facility and the Central Flow Control Facility with a significantly improved capability to process and disseminate aviation weather information.

Approach: The Central Weather Processor is being developed to receive, store, process, and distribute weather information in support of air traffic operations. Specifically, the functions of the processor are:

- Receiving and mosaicking weather radar data from multiple radars into an image covering the Area Control Facility's region of interest.
- Maintaining a complete data base of weather information applicable to the Area Control Facility's needs.
- Supporting an integral, interactive, automated meteorologist's workstation.
- Providing a systematic method for selective distribution of weather information tailored to the needs of particular users.
- Supporting automatic techniques to simplify and expedite the input and output of weather data and pilot weather reports.

The program will be implemented in two steps:

- The first step, Model I, will contain all the software and hardware to implement: mosaicking of weather radar images, workstation automation, satellite imagery processing, and integration of Automated Weather Observing System data.
- The second step, Model I Enhancements, will provide the software to accommodate the interconnection of the Central Weather Processor with evolving systems being developed in parallel with the Model I system, e.g. Advanced Automation System, Mode S Data Link, etc..

Products: Central Weather Processors will be provided to all Area Control Facilities, the Central Flow Control Facility, the FAA Academy and the FAA Technical Center.

Related Projects/Activities:

- The Radar Remote Weather Display System will provide weather radar information to the Central Weather Processor until replaced by Next Generation Weather Radar data.
- Next Generation Weather Radars will provide Doppler weather radar information to the Central Weather Processor.
- Automated Weather Observing System data will be provided to the Central Weather Processor by the AWOS Data Acquisition System.
- The Central Weather Processor will provide mosaicked weather radar data to the collocated Flight Service Data Processing System for dissemination to Automated Flight Service Stations.
- Weather data will be received from and transmitted to the National Weather Service via the FAA's Weather Message Switching Center Replacement.
- The Central Weather Processor will provide weather data to the Advanced Automation System.
- The Central Weather Processor will transmit weather products to and receive pilot weather reports from aircraft via the Weather Communications Processor which will support the Mode S data link.
- The Central Weather Processor will interface with the Maintenance Processor Subsystem to provide status information.
- Central Weather Service Unit personnel will communicate with controllers and Flight Service Station specialists via the Voice Switching and Control System.

Schedule:

- Production Specification - 1990
- Production Contract Award - 1991
- Field Implementation - 1992-1994

Project: Interim Voice Response System

Purpose: The Interim Voice Response System for self-briefing will permit pilots to retrieve information directly from an automated weather data base by telephone. This will assist in meeting the demand for service during the transition for Flight Service Station automation.

Approach: A contract was issued in February 1984 for installation, maintenance, and operation of a national system. Implementation was completed in October 1985. The entire system will be leased, and will provide service at 24 main metropolitan areas. The system is scheduled to operate through December 1989.

The areas to be served are:

Atlanta, GA
Boston, MA
Chicago, IL
Columbus, OH
Dallas/Ft. Worth, TX
Denver, CO
Detroit, MI
Harrisburg, PA
Houston, TX
Islip, NY (Long Island)
Kansas City, MO
Los Angeles, CA
Miami, FL
Minneapolis, MN
New Orleans, LA
Oakland, CA
Philadelphia, PA
Portland, OR
Raleigh, NC
Seattle, WA
St. Louis, MO
Teterboro, NJ (Metro NYC)
Washington, DC
Dallas, TX

The system will provide the following products: severe weather forecast alerts, convective SIGMETs, hourly surface observations, Terminal Forecasts, grid winds and temperatures aloft forecasts, and Transcribed Weather En route Broadcast forecasts.

Product: A communication network with computer processing nodes at 16 cities provides service to 24 metropolitan areas.

Related Projects/Activities: The Flight Service Automation System provides for a Voice Response System service to replace this system.

Schedule:

- Field Implementation - October 1985
- System Decommissioning - 1989

Project: Mode S/Data Link

Purpose: Mode S will improve the surveillance capability of the Air Traffic Control Radar Beacon System (ATCRBS). Mode S provides more accurate positional information and eliminates interference. This is accomplished by discrete interrogation of each aircraft and improved processing of aircraft replies. Mode S will also provide the medium for a digital data link which will be used to exchange information between the aircraft and various Air Traffic Control functions and data bases. This information will include weather data on a request/reply basis.

Approach: Mode S systems will be procured using multiple contracts. The first contract for 137 systems will provide coverage down to 12,500 feet above mean sea level (MSL) and to the ground at high-density terminals. The second contract for an additional 60 systems will extend this coverage down to 6,000 feet MSL or minimum instrument flight rules (IFR) en route altitude and above, whichever is higher. The systems are designed to be remote maintenance monitored and unmanned. Existing ATCRBS antennas not already capable of improved azimuth resolution will be replaced and/or additional antennas procured where increased data rates are required.

Mode S data link services will be developed and tested using the Mode S engineering test bed at the FAA Technical Center which will consist of a Mode S ground system and a number of transponders and related airborne input and display equipment.

Initial data link service will provide weather products available from existing weather data bases.

Subsequent data link services will also include data and functions which will originate from the Advanced Automation System.

Additional testing and development will be conducted to determine the applicability of extending the Mode S surveillance and data link capabilities to other functions.

Products:

- 197 Mode S systems will be developed at maximum production capability of 48 per year. In addition, 75 long-range radar monopulse antennas will be delivered.
- A Mode S/data link test bed.

- Mode S/data link national standard.
- Specification for Mode S antenna for long-range radars.

Related Projects/Activities:

The Traffic Alert and Collision Avoidance System may utilize Mode S format.

Long-range and terminal radar programs as well as en route and terminal Air Traffic Control automation activities may be coordinated with plans for Mode S implementation to assure compatibility of digital message formats.

The National Airspace System Interfacility Communications System User Access Network may provide the communications medium for data link services between Mode S sensors and the various sources of data and advisories.

Mode S will be a Remote Maintenance Monitored system.

Schedule:

- Contract Award - 1984
- First Delivery - 1987
- Initial Data Link Services - 1990
- Full Data Link Services - 1994

Project: Weather Message Switching Center Replacement

Purpose: To replace the Weather Message Switching Center with state-of-the-art equipment and technology to perform all current alphanumeric data handling functions of the current center, excluding Notices to Airmen processing. Further, the replacement will accommodate graphic data and function as the gateway to the National Meteorological Center.

Approach: Two systems will be procured for turnkey installation. To achieve geographic redundancy, there will be identical nodes, each capable of handling all system requirements in the event of a nodal failure. These nodes will be located in the National Airspace Data Interchange Network switching center buildings in Salt Lake City, UT and Atlanta GA. The replacement system is to be delivered in early 1989, with cutover and commissioning scheduled for late 1989.

Related Projects/Activities:

- National Airspace Data Interchange Network-II Phase I which provides communications connectivity and other networking support for the exchange of aviation weather data between current WMSC users and future NAS weather systems.

- Flight Service Automation System Aviation Weather Processor will interface to receive both alphanumeric and graphic weather data from NMC via the WMSCR.

- Central Weather Processor (CWP) will interface with the WMSCR via NADIN, to exchange both alphanumeric and graphic weather data.

Schedule:

- Procurement Specification - 1986
- Request for Proposals - 1986
- System Contract Awarded - 1987
- Field Delivery and Acceptance Testing - 1989
- System Operational - 1989

Project: Weather Communications Processor

Purpose: To act as the interface between airborne Mode S data link-equipped aircraft and pilot-desired weather products resident in the National Airspace System. The Weather Communications Processor will receive downlink requests for weather products from Mode S sensors, decode those requests, obtain the requested products from the appropriate National Airspace System source, format the reply, and return it to Mode S. The Weather Communications Processor will provide a direct link between the Mode S system and the National Airspace System weather data bases, greatly expanding the ability of the pilots to access desired information, and reducing the workload of specialists and controllers who currently represent the only means of such access.

Approach: An early capability for providing weather products via the Mode S data link will be installed. These products will be those for which automated data bases currently exist, or are planned to be operational in the near term. These include alphanumeric products such as surface observations, Terminal Forecasts, winds aloft, and pilot reports. These early products will be operationally tested to determine user acceptability and to aid in the process of fully defining the longer-term data link requirements.

Products:

- 25 WCPs
  - 23 to future ACFs
  - 1 to the FAA Academy
  - 1 to the FAA Technical Center

Related Projects/Activities:

- Mode S/Data Link - The WCP will interface with the Mode S data link to receive requests for weather products and route responses for transmission.

- FSAS - The WCP will interface with the FSDPS to receive weather products necessary to respond to pilot requests.

- RMMS - The WCP will interface with the Maintenance Processor Subsystem (MPS) for reporting of certification, status, and alarm data.

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- Central Weather Processor - The WCP will receive data link weather graphics products from the CWP.

- This project will require interfacility communications service from the National Interfacility Communications System. Projects providing that service include Radar Microwave Link (RML) replacement and expansion which will provide the communications network for transmission of data.

Schedule:

- Contract Award - 1987
- Test and Evaluation - 1989
- Implementation - 1989-1990

Project: National Data Interchange Network

Purpose: To analyze, design, and specify enhancements to the National Data Interchange Network to meet the data transfer requirements of major FAA programs and functions in the National Airspace System Plan for Facilities, Equipment and Associated Development.

This project will provide the expanded data switching capability and network monitoring functions required to meet the future FAA communications needs for data switching. Increased capacity, flexibility, and service availability will be achieved through the use of packet switching and a highly connected system architecture to replace the dual-star of NADIN IA.

Introducing packet nodes into the network will provide significant cost savings and performance upgrading.

Approach: Development of this system will result in specifications for concentrator-to-concentrator communications, packet switching nodes, and centralized network control and monitoring. As it evolves, this system will provide a cost-effective integrated, common user data transfer system which supports major FAA programs and functions. The resultant communications system will substantially reduce the number of dedicated, independent lines and their associated cost.

This system will be designed based upon the data flow requirements of new systems and consolidation. The project must be coordinated with other FAA communications initiatives in order to provide the required trunking and transmission facilities.

A highly connected network using packet data and packet switch nodes with a virtual circuit and alternate routing capability will be specified, as will a centralized network control and monitoring function. Standardization of access interface and exchange protocols will be maintained to ensure future flexibility of the system evolution. Message switching will continue to be provided by this network as well as a quick response, interactive data transfer, and efficient file (data base) transfer capability.

Specifications will be developed for expansion. Phase I will involve packet switching, packet nodes, and added trunking. Phase II will provide additional capacity, connectivity, and interfaces.

Products:

- Design Specifications for:
  - Concentrator-to-concentrator switching.
  - Packet switching.
  - Network control and monitoring.
  - Interfaces.

Related Projects/Activities: This system will interface with virtually all National Airspace System operational systems requiring interfacility data transfer. Future needs for the Area Control Facilities and Advanced Automation System will be met by this expansion. This system will be used to switch maintenance management system communications and will accommodate some Department of Transportation administrative data requirements.

Schedule:

- Phase I Contract Award - 1987
- Phase I Implementation - 1989
- Phase II Implementation - 1990

WEATHER RADAR IMPROVEMENT PROGRAMS

- Terminal Radar Program (ASR-9) (p. 7-19)
- Next Generation Weather Radar Program (p. 7-21)

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Project: Terminal Radar (ASR) Program

Purpose: To continue providing radar service economically at airports with air traffic densities high enough to justify the service, and to upgrade the higher density airports with the latest state-of-the-art equipment. Each of these radars will provide weather radar data via a separate weather channel.

Approach: Replacement of the Airport Surveillance Radars 4/5/6 is necessary because of the decreasing availability of spare parts and the high-maintenance workload. Repair parts availability for the Airport Surveillance Radars 4/5/6 will be critical by 1989.

Three separate activities have been combined to form this program.

- Replacement of 96 vacuum-tube Airport Surveillance Radars 4/5/6 with Airport Surveillance Radars 7/8/9.
- Procurement of 40 Air Surveillance Radar 9 systems to provide radar service at airports where the air traffic volume increases to a level requiring the coverage.
- Relocation of 56 existing solid-state radars as new construction interferes with required radar coverage and changes in air traffic volume make it necessary. This includes leapfrogging 16 Airport Surveillance Radars 7 to Airport Surveillance Radar 4/5/6 sites, and leapfrogging 40 Airport Surveillance Radars 8 to Airport Surveillance Radar 4/5/6 sites.

Data from all new radars will be remoted in digital format only.

Products: Replace 96 Airport Surveillance Radars 4/5/6, establish the minimum number of additional radars, and relocate 56 Airport Surveillance Radars 7/8 by 1990.

Related Projects/Activities:

- Air Surveillance Radar 9 installations are planned to precede Mode S installations by 6 months and must be coordinated.
- Automation facilities and sensor sites consolidation will be coordinated with en route and terminal automation replacements and consolidation.

- Frequency and spectrum engineering is involved with the terminal radar, long-range radar, and weather radar programs since these systems compete for pulse repetition frequency assignments in the same frequency bands.

- Changes to ARTS IIA will be required to accept Air Surveillance Radar 9 digital data.

- Air Surveillance Radar 7/8 facilities will require digitizing in a format compatible with the common radar network.

Schedule:

- ASR-9 Contract Award - 1983
- Field Installation - 1989
- Establish Digital Interface - 1986/1993
- Relocate ASR-7/8s - 1987/1990

Project: Next Generation Weather Radar Program

Purpose: To provide accurate, and timely information on severe thunderstorms, tornadoes, precipitation, reflectivity, turbulence and wind shear, and other types of hazardous weather and related events, to meet weather radar information requirements in support of NWS, Air Weather Service, Naval Oceanography Command, and FAA missions.

Approach: The FAA, National Weather Service, and Department of Defense will jointly define, develop, and test the new long-range Doppler weather radar system. Contracts for preproduction development were awarded in 1983. Following completion of test and evaluation, production units will be procured for deli- veries between 1988 and 1994. An initial procurement of 10 units will be followed by a production procurement of 169 units. The final number of production units may be adjusted dependent upon the agencies specific requirements.

Products:

Next Generation Weather Radars will be located as follows:

Continental United States - (joint purchase with FAA, National Weather Service, and Air Weather Service)	113
DoD CONUS (USAF)	22
Non-Continental United States (FAA)	13
DoD Non-CONUS (USAF, USN)	24
Engineering & Training Systems	7
	179

Related Projects/Activities: The FAA's weather radar system of the future will consist of the following major components:

- The Next Generation Weather Radar described above;
- The improved Airport Surveillance Radar (ASR-9);
- Associated Communications; and
- Terminal Doppler Weather Radar.

Radar data from the Next Generation Weather Radars will be transmitted to the Central Weather Processor for processing into a radar mosaic map of the control area for display to pilots, air traffic controllers and Center Weather Service Unit meteorologists.

Schedule:

- Prototype Contract Award - 1984
- Limited Production Contract Award - 1986
- Full Production Contract Award - 1987
- Limited Production Delivery - 1988
- Full Production Delivery - 1992

WEATHER OBSERVATION SYSTEMS AUTOMATION PROGRAMS

- Automated Weather Observing System (p. 7-25)
- Runway Visual Range Systems - New Generation (p. 7-27)
- Low Level Wind Shear Alert System Enhancements (p. 7-29)

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Project: Automated Weather Observing System

Purpose: To obtain aviation critical weather data (e.g., wind velocity, temperature, dew point, barometric pressure, cloud height, visibility, and precipitation occurrence and accumulation) through the use of automated sensors; process the data; and allow the dissemination of this information to users.

Approach: AWOS dissemination methods to be tested are:

- Computer-synthesized voice broadcast over a VHF communication outlet (VOR or discrete frequency) which is updated once each minute.
- Flight Service Station specialist and direct user telephone access through the Flight Service Automation System. Prior to FSAS establishment, local AWOS data will be directly displayed to specialists.
- ATCT controller access to local AWOS data through the use of cathode-ray tubes with manual entry devices located in ATCTs. Data being displayed will be the current data broadcast.
- Entry transmission into a national network for ATC application.

The acquisition of AWOS will be accomplished in two phases--demonstration and production. Competitive contracts for the 14 system demonstration phase were awarded in December 1982. The demonstration phase was completed in July 1984. During this phase the production specification was completed and production procurement initiated. Implementation of the production system will begin by late 1987.

Specifications developed will also allow the acquisition of affordable AWOS sensors, processors, and display devices by airport operators, fixed based operators, heliport operators, etc., for their needs.

Products:

- 441 Nontowered airports/heliports and Flight Service Stations (F&E funded).
- 304 Towered airports (F&E funded).
- 4 Heliports

Projected Non-Federal Installations:

- 400 Nontowered airports (AIP funded).
- 600 Local.

Related Projects/Activities:

- Automated Weather Observing System data will be broadcast over VORs or discrete VHF/UHF outlets.
- Observation data will be furnished to control towers on a display for the controller's use in preparation of the Automatic Terminal Information Service broadcast.
- Observation data will be transmitted via National Airspace Data Interchange Network to FAA and NWS facilities. The AWOS Data Acquisition System will provide centralized collection, processing and distribution of surface weather observations from all automated observing systems within the jurisdiction of each Area Control Facility.
- Observation data will be part of the data base supplied to Flight Service Data Processing System and Central Weather Processor for eventual use by air traffic controllers and Center Weather Service Unit meteorologists in Area Control Facilities and towers.
- Observation data will be part of the messages being transmitted to pilots via the Mode S data link.
- These data will also be available on VRS and DUAT, and to the FSS Specialists for briefings.
- Rotorcraft program - AWOS development will support the surface observation needs of FAA's rotorcraft programs as well as short-term forecasting.

Schedule:

- Production Specification Completed - 1985
- Production Contract Awards - 1986; 1991
- Production and Installation - 1987-1996

Project: Runway Visual Range Systems - New Generation

Purpose: To provide an instrumentally derived value of Runway Visual Range to estimate how far a pilot could see down the runway under the existing conditions.

This system represents a new generation of Runway Visual Range system which will replace the current systems operating in the NAS today. The Runway Visual Range system will be associated with Instrument Landing Systems or Microwave Landing Systems. It will measure Runway Visual Range values under reduced visibility conditions caused by fog, rain or snow at the touchdown, midpoint and rollout points of the instrument runway.

Existing systems include Runway Visual Visibility systems and several early generations of Runway Visual Range systems consisting of:

- 45 Runway Visual Visibility systems
- 18 Runway Visual Range systems (IRA-Manufacturer)
- 37 Solid State Radiation Runway Visual Range systems
- 83 Tasker 400 Runway Visual Range systems
- 242 Tasker 500 Runway Visual Range systems

These systems provide Runway Visual Range information to pilots via controllers in support of Category I, II, and IIIa operating conditions down to 600 feet Runway Visual Range. The new generation of Runway Visual Range systems will meet and exceed these operating conditions by satisfying the requirements of Category IIIb operating conditions down to 150 feet Runway Visual Range.

Products:

	Locations
Category IIIb	39
Replace Runway Visual Range Systems with New Generation	386
Establish Runway Visual Range	275

Related Projects/Activities: RVR information is required for aircraft using Instrument Landing Systems and Microwave Landing Systems. All Category II facilities require Runway Visual Range; however, weather conditions and facility operations must meet Airway Planning Standards No. 1 criteria if Runway Visual Range is to be installed on Category I runways with Instrument or Microwave Landing Systems.

Schedule:

- Install Systems for interim Category IIIb operations - 1986/1988
- Replace all existing RVR equipment with the new generation - 1988/1992

Project: Low Level Wind Shear Alert System Enhancements

Purpose: To provide pilots, through the tower controllers, with improved information on the occurrence of low level wind shear conditions which may be hazardous to aircraft during takeoff or final approach.

Approach: The Low Level Wind Shear Alert System program is an ongoing effort which, when completed, will provide 110 systems. The basic system consists of a center field anemometer at the airport and a small number of anemometers (typically four) located a few kilometers away from the airport. Wind shear is determined by calculating the vector difference between the wind at a boundary location and the centerfield sites. The threshold for an alert is 15 knots. The alert consists of both visual and aural alarms to the controller.

An enhanced system consisting of ten remote units will be installed at the New Orleans International Airport. All the data will be recorded and analyzed to determine the benefits of increasing the number of boundary sensors.

SUPPORTING RESEARCH PROGRAMS

- Terminal Doppler Weather Radar (p. 7-33)
- Aircraft Icing (p. 7-35)
- Very Short-Range Statistical Forecasting of Automated Weather Observations: GEM Program (p. 7-36)
- Very Short-Period Terminal Forecasting (0-4 hours) (p. 7-37)
- Short-Period Terminal Forecasting (0-12 hours) (p. 7-38)
- Wake Vortex Avoidance System (p. 7-39)

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Project: Terminal Doppler Weather Radar

Purpose: To provide a radar tailored to meet FAA requirements for wind shear and other hazardous weather detection in the terminal environment.

Approach:

- This program will provide the capability for microburst and wind shear detection in both clear/dry and moist environments primarily at low altitudes in terminal areas. Wind shear detection requires a Doppler radar capability with a fast update rate and automated hazard detection, relatively high power, and sophisticated ground clutter suppression. Terminal approach and departure area coverage necessitates siting near or at the concerned airport.

- Two major projects have been undertaken within this program:

  1. A Doppler weather radar test site was established in 1984 at Olive Branch, Mississippi, that is approximately 12 miles southeast of Memphis International Airport. The radar is a NEXRAD type, S-band Doppler weather radar based on an ASR-8 radar with a Lincoln Laboratory built Doppler processing capability. The test bed radar is currently operated in the following mode:

     - As a terminal Doppler radar to detect low-altitude wind shear and other hazards both "on-airport" and "off-airport".
     - As a NEXRAD "network" sensor with a 6-minute volume scan and principal focus on products of particular interest to the FAA such as turbulence, layered reflectivity, and low-altitude wind shear.

  The objectives of this project are:

  - To resolve the principal uncertainties in algorithms for detection and display of en route and terminal hazardous weather regions.

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- To obtain feedback from operationally oriented users on the utility of proposed products for improving safety and efficiency of airspace utilization.

- To provide a data base for FAA specification of NEXRAD, Terminal Doppler Weather Radar, and NEXRAD/Central Weather Processor interfaces.

2. The CLAWS (Classify, Locate, and Avoid Wind Shear) project was conducted at Denver's Stapleton International Airport from July 7, 1984 through August 15, 1984. The project involved the use of a National Center of Atmospheric Research experimental Doppler radar and a team of dedicated radar meteorologists and forecasters to provide real-time operational support to the Denver Airport Traffic Control Tower. Data were used from the Program for Regional Observing and Forecasting Services. A number of operational hazardous weather products were developed and utilized during the project. They included a daily microburst outlook, present weather status, microburst advisory, wind shift advisory, and thunderstorm initiation advisory. While the principal reason for CLAWS was microburst advisories, the wind shift and thunderstorm initiation advisories also proved highly useful to the overall airport traffic operation. The primary objective of the project was to demonstrate the applicability of microburst forecast and warnings in an operational airport environment.

Related Projects/Activities: NEXRAD, Low Level Wind Shear Alert System Enhancements and Joint Airport Weather Study follow-on analysis.

Project: Aircraft Icing

Purpose: To develop and document a current technology base for regulatory actions to refine standards and advisory materials related to icing conditions. This research should ensure that the technology base exists to fully support safe, timely, and cost-effective compliance with aviation safety regulations.

Approach: Current icing certification standards were developed approximately 30 years ago. Advisory Circular 20-117, "Hazards Following Ground Deicing and Ground Operation in Conditions Conducive to Aircraft Icing", was issued in 1983. Considering the dramatic changes in aircraft technology, these standards require revision to develop the technological bases needed to support the development of regulations, procedures, and guidance material. This includes:

- the development of atmospheric characterization for all types of icing conditions worldwide and the updating of FAA regulations which are pertinent,
- the use of simulation, airborne test facilities and ground based facilities for the development of a simulator technology handbook which would provide an acceptable means of demonstrating compliance to certification standards,
- development of anti-icing, deicing and ice detection systems and production of an aircraft icing handbook, particularly for helicopters,
- development, validation, and application of analytical icing models; and
- improvements in aviation oriented forecasts, better identification of specific hazards, and improved dissemination.

Products:

- New and/or revised icing atmospheric characterization.
- Revised simulation criteria.
- Equipment and methodology certification handbook.
- Updated ground deicing advisory materials.
- Aircraft Icing Handbook.

Related Projects/Activities: Airworthiness; Weather Sensor Development.

Project: Very Short Range Statistical Forecasting of Automated Weather Observations: GEM Program (Generalized Equivalent Markov)

Agency: GEM is an NWS program supported by the FAA

Approach: Rotorcraft pilots have little interest in mid-range (4-6 hours) weather forecast. What is needed is short range (10-120 minutes) forecasts for short range distances. GEM is a statistical technique for predicting the probability distribution of all surface weather elements hour-by-hour. It uses only the current local automated surface weather observations elements as predictors. From these probability distributions, categorical predictions are made for each automated surface weather element. The model is founded on a Markov assumption and utilizes multivariate linear regression as the statistical operator.

Related Project: AWOS, ASOS

Project: Very Short Period Terminal Forecasting (0-4 hours)

Purpose: To develop an improved very short period weather forecasting capability providing pilots with more accurate and reliable weather information for both tactical and strategic planning purposes.

Approach: One responsibility of the NOAA Program for Regional Observing and Forecasting Services is to address the short-period local area weather forecasting problem by bringing together in one system real-time data sources, sophisticated computational processing, interactive display and short-term forecasting routines. The real-time data sources include satellite; radar, including Doppler; automated regional surface observations; and national scale data. Extensive, real-time computing power is required to test the potential of various forecasting algorithms, and to interactively display the results. This capacity has been implemented within the Program. The very short-period forecast technique development program can utilize all of the program's hardware and software capability to advantage at fractional costs.

The establishment of a local very short period (0-4 hours) forecast technique development capability and an operational test center for local terminal forecasting technique evaluation will permit:

- Evaluation of the importance of specific data sets;
- Evaluation of the applicability of various forecasting techniques; and
- Recommendation of techniques for operational implementation by NWS in the FAA's automated Center Weather Service Unit workstation.

Related Projects/Activities: Central Weather Processor; Next Generation Weather Radar; Terminal Doppler Weather Radar; Wind Shear Efforts; Joint Airport Weather Studies Follow-on; Air Force Geophysics Laboratory Mesoscale Techniques Development; National Severe Storms Laboratory Numerical Model of Convective Weather; Very short-range Statistical Forecasting of Automated Weather Observations: GEM (Generalized Equivalent Markov).

Project: Short Period Terminal Forecasting (0-12 hours)

Purpose: To improve the short period efficiency of aviation operations by reducing weather related delays and weather related accidents; and to overcome the lack of forecasts for general aviation heliports and terminals, and provide fully automated short-range forecasts.

Approach: An accurate forecast of poor weather conditions can prevent the unnecessary and costly initiation or continuation of a flight. This program will attempt to develop statistical techniques and algorithms to predict terminal weather parameters up to 12 hours in advance. The algorithms will be developed and tested for public use airports/heliports.

Products: A report describing the algorithms and the recommended approach for implementation will be prepared. The report will address the computer capacity and processing required.

Related Projects/Activities: Central Weather Processor; Next Generation Weather Radar; Terminal Doppler Weather Radar; Wind Shear Efforts; Joint Airport Weather Studies Follow-on; Air Force Geophysics Laboratory Mesoscale Techniques Development; National Severe Storms Laboratory Numerical Model of Convective Weather.

Project: Wake Vortex Avoidance System

Purpose: To develop wake vortex avoidance methods and procedures based upon knowledge gained from the study of the forces that generate aircraft wake vortices and the effect of varied meteorological conditions on the generation, transport and decay of wake vortices.

Approach: An analysis of wake vortex transport and decay data is being undertaken to determine the impact of wake vortices near the ground, and their consequences for operations on closely spaced parallel runways.

An analysis of wake vortex transport and decay is being coupled with computer routines which will be used for the evaluation of operational alternatives, for site-specific airports, aimed at increasing airport capacity. Analyses will then determine whether or not wake vortices will pose a problem for the proposed procedural improvement scenarios.

A program has been initiated to determine the effects that wind, wind gradient, turbulence, temperature, temperature gradient, atmospheric stability, pressure, and humidity have on the generation, transport, and decay of wake vortices. This research work may result in the establishment of new separation standards based on easily measurable meteorological factors.

An effort will be undertaken to investigate rotorcraft wake vortex and downwash. The results of this investigation may lead to new separation standards for rotorcraft.

Products:

- Program plan for rotorcraft wake vortex and downwash.
- Computer routines for wake vortex analyses.
- Wake vortex avoidance system design document.
- Wake vortex prediction system design document.

Related Projects/Activities: Airport Capacity Improvement/ Delay Reduction, Rotorcraft Procedures.

8. NON-FAA WEATHER SYSTEM DEVELOPMENT PROGRAMS

In addition to the FAA-sponsored programs described earlier, there are programs sponsored by other agencies, or joint projects, which are related to the Aviation Weather System Plan. This relationship may be an actual interface between the programs (e.g. the Air Force's Satellite Data Handling System will interface with the Automated Weather Distribution System) or it may result from a similarity between programs of different agencies (e.g. FAA's Automated Weather Observing System and NWS's Automated Surface Observing System). The Office of the Federal Coordinator for Meteorology (OFCM) assures the coordination and cooperation among the Federal agencies involved in weather-related activities so that the best weather information is available to the users. OFCM also reviews the set of Federal weather programs and total Federal requirements for weather services. Described in this section are the most significant weather-related programs conducted by other agencies or conducted jointly by several agencies. Emphasis has been placed on those programs directly related to aviation and the major programs of other agencies which are concerned with advancing the state-of-the-art in meteorological observation and forecasting. Only ongoing or planned programs are described.

The programs are organized into six areas which are not mutually exclusive. The programs which have applicability in more than one area have been described in the subsection judged to be most pertinent. The six program areas are:

1. Automated Weather Information Systems - This area includes both the large multi-location networks and individual single location systems such as the Centralized Storm Information System at the National Severe Storms Forecast Center in Kansas City.

2. Weather Radar - this area includes conventional and Doppler radar related projects.

3. Surface Observation Programs - This area includes both the automated observation system development and the individual observational techniques.

4. Upper Air Observation Programs - Both the individual techniques and communications (data reporting) programs are described.

5. Specialized Programs - Large scale programs and individual projects of special importance to aviation (e.g. icing, low level winds) are described.

6. Meteorological Modeling - Significant programs, which may not have a direct immediate impact on aviation weather, but are aimed at advancing the state-of-the-art in meteorology.

AUTOMATED WEATHER INFORMATION SYSTEMS

- Advanced Weather Interactive Processing System for the 1990s (p. 8-5)
- Satellite Weather Information System (p. 8-7)
- Automated Weather Distribution System (p. 8-8)
- Naval Environmental Display Station (p. 8-10)
- Meteorological Measurement System (p. 8-11)
- Satellite Data Processing and Display System (p. 8-12)
- Standard Formats for Weather Data Exchange among Automated Weather Information Systems (p. 8-13)
- Program for Regional Observing and Forecasting Services (p. 8-15)
- Centralized Storm Information System (p. 8-18)
- Satellite Data Handling System (p. 8-19)

Project: Advanced Weather Interactive Processing System for the 1990s

Agency: DOC/NOAA/NWS

Purpose: To provide a modern integrated weather information processing, display and communication system for field operation.

Approach: NWS has authorized the development of this system, formerly called System II, as a follow-on to the NWS Automation of Field Operations and Services system. This advanced automated weather information system is planned for use at most NWS field offices in the 1990s as an aid in providing multiple weather services to the nation. It will be the primary office workstation, with a master data base to integrate, assimilate, and display all relevant weather and hydrologic information. The system will aid the local forecaster in producing more precise and timely forecasts, and is planned for use at approximately 130 field offices.

An inherent feature of this system is the real-time collection, storage, and display of digital satellite and radar imagery and their combined use with conventional upper air and surface data. Forecasters will fully examine and manipulate the contents of a comprehensive mesoscale data base through interactive techniques. Also included will be the necessary communications for internal distribution of data guidance products and satellite and radar imagery, and for interfacing with observing and dissemination systems. This system will not take observations (but will provide a central collection point for observing systems), nor will it directly disseminate information to the public and other users.

Related Projects/Activities:

- The Naval Environmental Display Station is the Navy's operational automated weather information system.
- The Automated Weather Distribution System is the Air Force's planned automated weather information system for the late 1980's to 1990's.

- The Working Group on Automated Weather Information Systems of the Federal Coordinator for Meteorology is developing format standards for interchange of data among the major automated weather information systems.
- The NWS is using the Program for Regional Observing and Forecasting Services as a testbed for evaluating advances in research and technology for transfer into operational use with this system.

Project: Satellite Weather Information System

Agency: DOC/NOAA/NWS

Purpose: To provide a weather satellite imagery capability at selected National Weather Service Offices.

Approach: The National Weather Service is in the process of acquiring a weather satellite imagery storage and display system. Forty-five systems will be procured. An option to obtain twenty-five additional system is included on the contract. The systems will acquire the desired imagery via the Geostationary Operational Environmental Satellite Tap distribution system from Satellite Field Service Stations. Storage for 500 images will be provided. The capability to overlay Automation of Field Operations and Services graphics on the satellite imagery will be provided. Data may be displayed in four colors. The system will include a manual graphics tablet.

Related Projects/Activities:

- This system is functionally similar to the Navy's Satellite Data Processing and Display System.
- This system is functionally similar to the Air Force's Satellite Data Handling System.

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Project: Automated Weather Distribution System

Agency: DoD/U.S. Air Force/Air Weather Service

Purpose: To provide satellite, graphic and alphanumeric weather data storage, processing and display at selected U.S. Air Force and Army installations in the United States and overseas.

Approach: This system will provide rapid, efficient, tailored weather support with fewer people by automating labor-intensive tasks and communications. This system will consist of seven functional areas as follows:

1. Communications/Data Management
2. Base Weather Station Forecaster Terminal
3. Staff Weather Officer/Wing Weather Officer Terminal
4. Aircrew Briefing Terminal
5. Observer Terminal
6. Flight Control Facility
7. Notice-to-Airmen Terminal

A modular design will permit this system to be operated in a fixed or mobile environment, and minimize staffing requirements.

The U.S. and Canadian governments have entered into an agreement that Canada could provide up to 50% of the development costs of selected joint projects if the prime development contractor is a Canadian firm. This system was selected as one of these projects. The prime development contractor is MacDonald/Dettwiler and Associates, LTD of Vancouver with the Canadian government subsidizing development at the 50% level. After development, the Air Weather Service and Canada's Atmospheric Environment Service will be independently responsible for obtaining the operational systems they desire. The money for the Air Force's production systems is not guaranteed. The production decision is scheduled for June 1987.

Related Projects/Activities:

- The Naval Environmental Display System is the Navy's operational automated weather information system.

- The Advanced Weather Interactive Processing System is the NWS's planned automated weather information system for the 1990's.

- The Working Group on Automated Weather Information Systems of the Federal Coordinator for Meteorology is developing format standards for interchange of data among the major automated weather information systems.

Project: Naval Environmental Display Station

Agency: DoD/U.S. Navy/Naval Oceanography Command

Purpose: To provide interactive tools for oceanography center meteorologists to view, create, edit and disseminate alphanumeric and graphic weather information for naval operations.

Approach: The U.S. Navy has designed and implemented this system to support weather briefing and analysis requirements of Navy meteorologists. This system receives alphanumeric and graphic data from the Fleet Numerical Oceanography Center via Naval Environmental Data Network. For alphanumeric data, the Air Force's Automated Weather Network and the Automated Digital Network are also available. This system has been operational at major naval centers for several years. Production and testing of enhanced units began in 1984. (See details under Satellite Data Processing and Display System.)

Related Project/Activities:

- The Meteorological Measurement System will provide an environmental measurement and display capability in support of U.S. Navy command and control activities. It includes this system.
- The Satellite Data Processing and Display System will enhance this system by providing satellite weather images at six major oceanography centers.
- The Advanced Weather Interactive Processing System for the 1990s is the NWS's planned automated weather information system for the 1990s.
- The Automated Weather Distribution System is the Air Force's planned automated weather information system for the late 1980s to 1990s.
- The Working Group on Automated Weather Information Systems of the Federal Coordinator for Meteorology is developing format standards for interchange of data among the major automated weather information systems.

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Project: Meteorological Measurement System

Agency: DoD/U.S. Navy

Purpose: To develop an environmental measurement and display capability in support of Command and Control.

Approach: This system's capability will enable: (1) measurement of on-scene environmental parameters to assess/predict the effect of the environment on performance of weapons systems developed in the Tactical Environmental Support System and needed to support airborne missions such as Anti Submarine Warfare and Airborne Early Warning; and (2) processing, communication, storage and display of environmental data and derived products. This system includes E-2 Aircraft Microwave Refractometer, P-3/S-3 Aircraft Dropsonde, shipborne/airborne remote sensors, and the entire family of Naval Environmental Display Stations.

Related Projects/Activities:

- The Naval Environmental Display Station system is a component of this system.
- The Satellite Data Processing and Display System will be a component of this system.

Project: Satellite Data Processing and Display System

Agency: DoD/U.S. Navy

Purpose: To provide an environmental satellite imagery capability to selected Naval Environmental Display Stations.

Approach: The Navy is in the process of enhancing the Naval Environmental Display Stations at seven major locations by incorporating an Environmental Satellite Acquisition and Display System at each station.

Related Project/Activities:

- This system will be an enhancement to selected Naval Environmental Display Stations.
- This system will be a component of the Navy's Meteorological Measurement System.

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Project: Standard Formats for Weather Data Exchange among Automated Weather Information Systems.

Agency: DOC/NOAA/Federal Coordinator for Meteorological Services and Supporting Research/Working Group on Automated Weather Information Systems

Purpose: To provide a common set of formats to be used for the transfer of weather data among agencies, principally the Air Force, Navy, National Weather Service and Federal Aviation Administration.

Approach: Under the direction of the Federal Coordinator's office, a working group was established to develop a set of standard formats for weather data exchange. The objectives of the program are:

1. To provide a level of data structuring above the communications level, that is not dependent on the networking and data link procedures.

2. To provide a format that will support all existing products and message data, both graphic and nongraphic.

3. To provide a device-independent format that will allow for expansion to handle new data structures or graphics devices without having to redefine the general structure of the format.

4. To provide a format that will be both convenient for the host machine to generate and for the receiving equipment to process.

5. To provide a format that readily allows receivers to bypass data formats not usable at the receiving station.

6. To provide a format which is byte oriented with 8 bits per byte.

The initial format standards document was published in August 1982 (FCM-S2-1982). Present activities of the working group include: updating and revision of the standards as necessary; preparation of a policy document on the use of such standards; development of a set of standards on network interface; and initiation of an annual report on the status of automated weather information systems.

Related Project/Activities:

- The three major automated weather information systems (National Weather Service, Air Force and Navy) will use the standard formats at least for transfer of weather data among agencies.

Project: Program for Regional Observing and Forecasting Services

Agency: DOC/NOAA/NWS

Purpose: To improve weather services by testing and evaluating advances in research and technology for transfer into operational programs, particularly the Advanced Weather Interactive Processing System of the 1990s.

Approach: This program operates an Exploratory Development Facility with five Digital Equipment Corporation computers plus other smaller computers, multiple sources of real-time meteorological data, several advanced forecasting workstations, and a library of software. Real-time meteorological data sources include:

- Doppler and conventional radars
- Geostationary Operational Environmental Satellite imagery
- A surface mesonet of 22 stations
- Access to Denver Urban Drainage District data
- National Meteorological Center model outputs
- The Aeronautical Radio, Inc. line
- Experimental vertical wind Profilers operated by the Environmental Research Laboratory

Major current and planned activities related to the improvement of aviation weather information include:

1. Advanced Weather Interactive Processing System for the 1990s.

   a. In 1986, a workstation will be installed in the Denver Weather Service Forecast Office as a field demonstration of a possible Advanced Weather Interactive Processing System.

   b. In 1988, a ten station network of workstations will be installed in the Kansas, Missouri and Oklahoma areas for field demonstration.

   c. Also in 1988, a thirty station network will be installed in the same Kansas, Missouri, and Oklahoma areas to provide satellite atmospheric sounding data and ground based Profiler data to the forecast stations.

2. The CWSU PROFS Advanced Weather Support Evaluation Project (AWEP) was initiated in April 1982 at the request of the Denver ARTCC to help alleviate the serious impact on the entire ATC system of adverse weather situations at centrally located Denver Stapleton International Airport. This PROFS workstation provides a unique capability at the Denver ARTCC for testing current aviation weather service technology and evaluating controller operational display requirements.

A fully interactive CWSU PROFS workstation is now operating on an experimental basis at Denver. Phase I of the project was successfully completed. Phase II evaluation program is currently underway and will continue through 1986.

3. An ongoing effort to develop algorithms for use in Central Weather Processor forecasting will continue through 1986. Development will include algorithms for icing, cloud tops, ceiling/visibility analysis, grid conversion, interactive sounding analysis, and turbulence detection.

4. This program will also provide support to the FAA's Terminal Doppler Weather Radar program through the National Center for Atmospheric Research. Primary emphasis will be on algorithm development and optimal information display to controllers for relay to pilots.

5. This program will provide ongoing support to the development of Next Generation Weather Radar algorithms and will also address problems of the Next Generation Weather Radar/Advanced Weather Interactive Processing System for the 1990s interface.

6. This program will provide ongoing support to studies for improved forecasts on the 2 to 12 hour time scale. The studies will continue from the present to the 1989-1990 time period.

Related Projects/Activities

- Advanced Weather Interactive Processing system for the 1990s development is being supported by many of the Program for Regional Observing and Forecasting Services efforts.

- Central Weather Processor development is being supported by specific programs at the program's facility.
- Next Generation Weather Radar development is being supported by this program's algorithm development and by Next Generation Weather Radar/Advanced Weather Interactive Processing System for the 1990s interface studies.

Project: Centralized Storm Information System

Agency: NOAA and NASA

Purpose: To provide a computer-based image display system and workstation at the National Severe Storms Forecast Center in Kansas City, MO.

Approach: A computer-based image display system has been installed at National Severe Storms Forecast Center. The system, which locates, rectifies, scales and displays a wide variety of meteorological information including satellite images, radar plots, synoptic analyses and upper air data on video consoles is currently undergoing operational evaluation. The system architecture is similar to that of the automated weather information system in use at the University of Wisconsin. Additional design input was provided from NASA's Minimum Energy using Interactive Techniques project. NASA's participation in the joint effort is completed.

Related Projects/Activities:

The following automated weather information systems or projects involve graphics and/or alphanumeric display. Some also involve input workstations. For these reasons they are functionally related to this system:

DOC/NOAA - Advanced Weather Interactive Processing System for the 1990s
DOC/NOAA - Program for Regional Observing and Forecasting Services
U.S. Navy - Naval Environmental Display Station
U.S. Navy - Meteorological Measurement System
U.S. Navy - Satellite Data Processing and Display System
U.S. Air Force - Automated Weather Distribution System
U.S. Air Force - Satellite Data Handling System
NASA - Minimum Energy Using Interactive Techniques

Project: Satellite Data Handling System

Agency: DoD/U.S. Air Force/Air Weather Service

Purpose: To provide a comprehensive weather graphics system for use at the Air Force Global Weather Central.

Approach: In 1979, a contract was awarded for the development of a Satellite Data Handling System and an Interactive Processing and Display System for use at the Air Force Global Weather Central. At present, the functions of the two systems have been integrated into the former and the later is not being developed as a separate system. This system is planned to be fully operational in 1986.

Among the functions being planned for this system are:

- A complete graphics display system that includes an interactive workstation. The workstation will allow automated plotting, overlaying, tracing, posting and sorting. Graphics capability will include meteorological satellite imagery, National Meteorological Center graphics, and in-house created graphics.
- The system will serve as the graphics product driver for Automated Weather Distribution System equipment. In this capacity graphic products will be created or retransmitted from other sources and shipped via a 9600 bit per second circuit to domestic Base Weather Stations which are components of the Automated Weather Distribution System. 4800 bit per second circuits will be used for transmission to European and Pacific equipment.

Related Projects/Activities:

- This system will interface with Air Force Base Weather Station Automated Weather Distribution System equipment via 9600 or 4800 bit per second communications circuits.
- This system may interface with NWS circuits for the exchange of National Meteorological Center or Air Force graphics information, particularly in a backup mode.

- This system may interface with Navy circuits for the exchange of graphics information particularly in a backup mode.
- This system may be required to adhere to graphics standards established by the Working Group on Automated Weather Information Systems of the Federal Coordinator for Meteorology.

WEATHER RADAR PROGRAMS

- Display and Interpretation of Doppler Weather Radar Data (p.8-23)
- Airborne Doppler Radar for Wind Shear Detection (p. 8-24)
- Carbon Dioxide Laser Doppler System for Low Level Wind Shear Observations (p. 8-25)

Project: Display and Interpretation of Doppler Weather Radar Data

Agency: DOC/NOAA/National Severe Storms Laboratory

Purpose: To develop Doppler weather radar displays for real time interpretation of data.

Approach: With the support and cooperation of the Federal Aviation Administration, the National Weather Service, the United States Air Force Air Weather Service, and the National Aeronautics and Space Administration, the National Severe Storms Laboratory is continuing studies to develop radar data displays for interpretation in real time. These studies are based on the demonstrated ability of pulsed Doppler radar to sense developing circulations 10-to-20 minutes prior to visual sighting of large tornadoes. A Doppler radar can also sense turbulence and wind motion in optically clear air and can, thus, depict fields of motion preceding cloud development. Funds permitting, the NSSL radars will be upgraded to develop operational techniques for use with the Next Generation Weather Radar, as well as to extend their ability to detect winds in clear air.

Project: Airborne Doppler Radar for Wind Shear Detection

Agency: NASA/FAA

Purpose: To develop a technique for airborne detection of wind shear and prediction of aircraft response.

Approach: NASA has been investigating the use of an airborne Doppler weather radar for the detection of wind shear. The program also includes the development of methods for predicting aircraft response to wind shear. NASA's objectives are to characterize hazards of short-lived microbursts and their impact on an aircraft's takeoff and landing performance.

Project: Carbon Dioxide Laser Doppler System for Low Level Wind Shear Observations

Agency: DoD/Air Force Geophysics Laboratory

Purpose: To develop a technique for predicting low level wind shear in the vicinity of terminals.

Approach: The Air Force Geophysics Laboratory is experimenting with a ground-based carbon dioxide laser system for observing low level atmospheric winds. Automated Doppler weather radar techniques are being adapted to the detection of meteorological parameters which are precursors to wind related severe weather events such as gust fronts, turbulence, mesocyclones, tornadoes and stratiform winds.

Related Projects/Activities:

- NASA's Upper Atmospheric Winds from Satellites program also uses a carbon dioxide laser for wind observations. However NASA's system will be satellite borne rather than ground based.

SURFACE OBSERVATION PROGRAMS

- Joint Automated Weather Observation Program (p. 8-29)
- Automated Surface Observation System (p. 8-30)
- Remote Sensing of Surface and Sub-Surface Parameters (p. 8-32)
- Automatic Meteorological Station (U.S. Army) (p. 8-33)
- Coastal Marine Automation Network (p. 8-34)
- Automated Sensor Development (p. 8-35)
- Surface Sensors Development (p. 8-36)

Project: Joint Automated Weather Observation Program

Agency: Office of the Federal Coordinator for Meteorology

Purpose: To provide policy guidance and oversight in the development of automated surface observation programs of the Departments of Commerce, Defense, and Transportation.

Approach: In response to guidance from the Office of Management and Budget, the three departments listed above formed this program. A Program Council was established and is chaired by the Federal Coordinator as an advisory member. The Council is composed of one representative from each of the three departments. The program is limited in scope to addressing the automated surface weather observation requirements of the three departments.

The program emphasizes modular design to permit partial implementation of automated systems as early as possible. Each of the three departments has active programs in the area of both systems and sensor development.

Related Projects/Activities:

The following programs fall under the scope of this program's activities:

- Automated Weather Observing System
- Automated Surface Observing System
- Automatic Meteorological Station (Army AN/TMQ-30)
- Coastal Marine Automation Network
- Automated Sensor Development (Air Force)
- Surface Sensor Development (NWS)

Project: Automated Surface Observation System

Agency: DOC/NOAA/NWS

Purpose: To implement a modular automated surface weather observing system capable of being deployed in various site-specific configurations and operated under a wide range of environmental conditions.

Approach: This program will augment manual observing systems at approximately 250 high density airports at an estimated cost of $70-75M over ten years. The observer may remain part of the observing process at these sites to provide present-weather discrimination and to provide coverage of unusual or non-homogeneous weather conditions. This program is expected to: (a) permit the redirection of 300 staff years for other purposes; (b) allow service consolidation; and (c) improve accuracy, provide a continuous watch and fill network gaps. This program will operate at two levels: A basic-level system designed to observe basic weather parameters essential to aviation and minimal forecast operations (when unattended) and sufficient for meteorological uses if augmented by observer inputs; and a full-automation system to observe all surface weather parameters essential to weather forecasting and services.

Program development efforts have been underway for some time, and the demonstration phase has been initiated. The demonstration is composed of a six site operational Kansas Pilot Project and a developmental Climatic Test-Bed Project. These projects are intended to provide early operational experience and support the refinement of the necessary hardware, algorithms and operational procedures. An ASOS system will be installed at the Kansas City downtown airport in the FAA control tower. The system is to be used on an experimental basis by air traffic controllers; the purpose of the test is to evaluate the system and determine the level of acceptance by air traffic controllers. The production system is scheduled for development during FY 1986 and implementation during FY 1987-1990.

Related Projects/Activities:

- This program comes under the Joint Automated Weather Observation Program Council activities.
- This program will probably be designed to provide automated direct input to the Advanced Weather Interactive Processing System for the 1990s.

- This program is very similar to the FAA's Automated Weather Observing System program.
- The NWS's Surface Sensor Development program should provide automated sensors for use with this program.

Project: Remote Sensing of Surface and Subsurface Parameters

Agency: DoD/Navy

Purpose: To develop remote sensing techniques for measurement of selected meteorological and oceanographic parameters.

Approach: The Navy has a number of related projects underway for developing remote sensing techniques for measurement of surface meteorological parameters and surface and subsurface oceanographic parameters. The projects include:

- Investigation of the practicality of measuring ocean surface and subsurface temperatures with a LIDAR.
- Development of electro-optic mapping technology to meet requirements for tactical aerial environmental survey in coastal regions.
- Development of shipboard LIDAR for routine measurement of water vapor, temperature, wind and sound transmission.
- Development of techniques to extract a number of environmental parameters from visual, infrared and microwave satellite data.

The program is evenly divided between sensor design and development, and processing and display applications. The processing and display efforts are divided between central site techniques and remote site direct readout methods.

Project: Automatic Meteorological Station (U.S. Army AN/TMQ-30)

Agency: DoD/U.S. Army

Purpose: To provide a mesoscale, short-life automated meteorological observing network in support of division size field operations.

Approach: The Army is developing the AN/TMQ-30, Automatic Meteorological Station, a system consisting of a master station, seven relay units and 36 remote sensor stations. This system is designed to provide surface observations within an Army division's zone of responsibility. The remote stations transmit, via digital radio frequency link, wind speed and direction, temperature, relative humidity, precipitation, and pressure data via direct line-of-sight or relayed link to the master station. The Remotely Monitored Battlefield Sensor System data transmission scheme is incorporated into the AN/TMQ-30. Transmission times are set hourly, or half hourly with a mission duration after deployment of 14 days. Stations can then be recovered, refurbished and reused. Microprocessor data control and processing are utilized throughout the system, in the remote sensor stations relay units and the master station. The system has completed the advanced development stage.

Related Projects/Activities:

- The Automatic Meteorological Station may come under of the Joint Automated Weather Observation Program Council activities.

Project: Coastal Marine Automation Network

Agency: DOC/NOAA Data Buoy Office

Purpose: To install and operate a network of automated weather observation stations on ocean buoy platforms, on offshore fixed platforms, and at U.S. Coast Guard shore locations.

Approach: Based on the individual site requirements and contraints, an environmental data system configuration will be selected for each site to meet NWS requirements. The data collected are processed on-site and reported in a directly readable World Meteorological Organization-format message. Communications to and from unattended sites is via the Geostationary Operational Environmental Satellite communications channel. Some land stations will also have a dial-up telephone link.

Related Projects/Activities:

- This program may come under the Joint Automated Weather Observation Program Council activities.
- Data from these stations may be automatically input to current and future National Weather Service automated weather information systems.

Project: Automated Sensor Development

Agency: DoD/U.S. Air Force Geophysics Laboratory

Purpose: Research and development for automated meteorological sensors for use at airfields and in tactical situations.

Approach: The Air Force Geophysics Laboratory has the primary responsibility for the development of automated meteorological sensors for use by the Air Force. Sensor development, test and evaluation are carried out at the laboratory's field site located at Otis Air Force Base, Falmouth, MA. Efforts are concentrated on the specification and prediction of airfield parameters for which an automated method does not presently exist. The work is also concerned with determining the availability and utility of instruments and techniques for providing weather information on parameters such as visibility and cloud height for Air Force tactical operations.

Related Projects/Activities:

- The Air Force's Automated Sensor Development Program may come under the Joint Automated Weather Observing Program Council activities.
- The Air Force's automated sensor program may support the development of sensors which automatically input data to the Automated Weather Distribution System.

Project: Surface Sensors Development

Agency: DOC/NOAA/NWS

Purpose: Research and development for new and improved techniques for measuring surface weather elements.

Approach: Meteorological instrumentation is being developed with primary emphasis on automating the sensing and dissemination of the data. Integration of automatic sensing equipment with existing or planned automated NWS equipment will allow for computer controlled collection and processing of observation data. Test and evaluation of weather equipment are conducted at the NWS field site in Sterling, VA.

Development work is divided into three parts. New sensors to replace current ones are under development for surface pressure, temperature/dew point, yes/no indication for precipitation, and freezing rain. In the near term, new sensors are being developed for determinaton of ceiling height (Laser Weather Indicator). For the future, sensors are being developed for determining the presence of hail, thunderstorm detection and measurement of snow depth.

Related Projects/Activities:

- Automated sensors will be integrated with the existing or planned NWS automated weather information systems.
- Automated sensor development may come under the Joint Automated Weather Observing Program Council activities.

UPPER ATMOSPHERE OBSERVING PROGRAMS

- Profiler (p. 8-39)
- Remote Atmospheric Sounding System (p. 8-41)
- Meteorological Data System (p. 8-42)
- Automated Aircraft Reporting Systems (p. 8-43)
- Aircraft to Satellite Data Relay System (p. 8-44)
- Upper Atmospheric Winds from Satellites (p. 8-45)
- Doppler Lidar for Measuring Upper Atmospheric Winds (p. 8-46)

Project: Profiler

Agency: DOC/NOAA/Wave Propagation Laboratory

Purpose: To provide continuous profiling of upper air winds, temperature and humidity; to assess the operational and research utility of a demonstration network of wind Profilers and to obtain meteorological observations for research program such as STORM.

Approach: The Profiler is a ground based tropospheric remote sensing laboratory prototype that provides continuous profiling of upper air winds, temperature and humidity. The system has two subsystems: a high-frequency Doppler radar provides vertical profiles of the three wind components, while a six-channel microwave passive radiometer provides the temperature and humidity profiles. In 1983, a temperature and moisture profiling system was installed at Denver's Stapleton Airport and a wind profiling system near Platteville, CO. Both systems transmitted 20 minute time-averaged profiles to the Program for Regional Observing and Forecasting Services Office and to the Denver Weather Service Forecast Office.

Development and testing of a commercial prototype is scheduled during 1985.

As part of the Wind Profiler Demonstration Project, and through the Wave Propagation Laboratory's Transfer Group, NOAA will deploy a network of 30 wind Profilers in the Colorado-Kansas--Oklahoma area by 1989 and operate it through 1992. Wind profile data will be collected, processed, archived, and distributed by a central (Hub) computer located in Boulder, CO to the ten station network of Program for Regional Observing and Forecasting Services workstations established in the same area. The individual Profilers will be clear-air Doppler radars designed to measure wind reliably from a few hundred meters above the ground to above the tropopause. Although initially designed only to measure winds, the electronics and communication parts of the Profiler will, at a later date, be able to handle the addition of temperature and humidity-sensing radiometers and surface instruments. During the field test, the National Weather Service and the Environmental Research Laboratory will jointly assess the network's performance. Other government agencies such as the Federal Aviation Administration and the Department of Defense, universities, and private industry will also take part in the assessment.

Likely uses of Profilers extend well beyond general weather forecasting by the National Weather Service. Data from a national network of Profilers could be used also for example to improve the routing of aircraft.

Related Projects/Activities:

- Profiler data are being gathered and evaluated by the Program for Regional Observing and Forecasting Services Office.
- Profiler data will be combined with satellite data from the Visible/Infrared Spin Scan Radiometer Atmospheric Sounder. The two complementary data sets will provide a significant enhancement to upper air observational capabilities.
- Data obtained during the Wind Profiler Demonstration Project may prove that a network of wind Profilers can support routine operations of the NWS and large experiments such as the Stormscale Operational and Research Meteorology project.

Project: Remote Atmospheric Sounding System

Agency: DoD/Air Force Geophysics Laboratory

Purpose: To provide vertical profiles of the atmosphere using remote sensing techniques.

Approach: The Air Force is investigating techniques for satellite-derived atmospheric soundings to provide a better worldwide density of such observations. In particular, profiles of temperature, water vapor, wind, and aerosol content are needed. Infrared radiance techniques would provide data on water vapor and temperature. In addition, suitable microwave frequencies may provide data for water vapor profiles. The data would be collected and processed for global analysis products such as computer flight plans and three-dimensional cloud analyses. The system will substantially improve the capability to collect such data.

Related Projects/Activities:

- The NWS's Profiler is also being developed to provide vertical profiles of the atmosphere using remote sensing techniques.

Project: Meteorological Data System

Agency: DoD/U.S. Army

Purpose: To modernize rawinsonde equipment used in support of artillery fire.

Approach: The Army is developing a new rawinsonde system to replace the aging AN/GMD-1 system currently in use. This new Meteorological Data System, AN/TMQ-31, will measure upper air wind velocity using passive tracking techniques such as Navaids or radio direction finding. The system will also provide temperature, humidity and pressure data for artillery support and other Army uses.

Project: Automated Aircraft Reporting Systems

Agency: DOC/NOAA/NWS

Purpose: To provide frequent, timely and accurate upper air data from aircraft equipped with Inertial Navigation Systems.

Approach: The Automated Aircraft Reporting Systems will provide the enhanced upper air data base needed for better aviation wind and temperature forecasts. From data-sparse land and oceanic areas, the Aircraft-to-Satellite Data Relay system will transmit from wide-bodied aircraft frequent, timely, and accurate upper air data via geostationary meteorological satellites. These data will be used in updating global weather prediction models. Over the United States, the meteorological component of the very high frequency Aeronautical Radio, Inc. Communications Addressing and Reporting System will provide a dense set of data at jet stream levels. These and the vertical profile data will be for use in regional numerical models. The high frequency version of this domestic system, while not fully demonstrated, shows promise of providing additional data from aircraft flying international routes. Data from these three systems and others can provide the dense data base required by advanced numerical models and interactive systems to produce substantially improved wind forecasts.

Related Projects/Activities:

- The Aircraft to Satellite Data Relay System has objectives which are very similar to the Automated Aircraft Reporting System.

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Project: Aircraft to Satellite Data Relay System

Agency: World Meteorological Organization (WMO) (assisted by the U.S. DOC, DoD, DOT and NASA)

Purpose: To provide frequent, timely and accurate upper air data via satellite.

Approach: This system is being developed to provide better and more frequent aviation wind and temperature observations from data-sparse land and oceanic areas. Data will be collected from commercial aircraft and relayed to ground based users via geostationary meteorological satellites. An important use of the data will be in updating global weather and fine-mesh prediction models.

Experimental aircraft-to-ground systems are being flown by a U.S. airline under NWS contract. The experience, tests and evaluation of these systems are being used in proposals made to the World Meteorological Organization for operational use of the system. A Working Group on Automated Aircraft Reporting has been formed under the Interdepartmental Committee for Meteorological Services and Supporting Research to provide a forum for program development which will meet national and international requirements.

Several prototype units are still operating. A contract was let in 1984 for design, fabrication, test and certification of a preproduction model. Initial deployment of production units is expected in 1986 with 80 system-equipped aircraft expected to be operational by 1990.

Related Projects/Activities:

- The Automated Aircraft Reporting Systems has objectives which are very similar to this system.

Project: Upper Atmospheric Winds from Satellites

Agency: NASA

Purpose: To provide wind observations for high altitude flights over oceanic and remote areas.

Approach: The measurement technique under study in this project employs a satellite-borne earth-viewing pulsed carbon dioxide laser. Back-scattered radiation from atmospheric aerosols can be combined with satellite navigation and beam-pointing information to calculate the movement of the aerosols. The aerosol velocity is assumed to be equal to the wind velocity.

Related Projects/Activities:

- Doppler Lidar Wind Measurements - Observations from NASA's ground-based Doppler Lidar system could be combined with data produced by this technique to provide complementary sets of upper atmospheric wind observations.

Project: Doppler Lidar for Measuring Upper Atmospheric Winds

Agency: NASA

Purpose: To provide upper atmospheric wind measurements by using a ground-based active remote sensor.

Approach: For a number of years NASA has been investigating remote sensing techniques for measurement of atmospheric parameters. As early as 1963, Lidar measurements of backscattering from tropospheric aerosols were made. With the development of Doppler Lidar techniques, the capability to detect the movement of atmospheric aerosols became available. The technique presently under study uses Doppler Lidar for the measurement of horizontal wind profiles from the surface to 30,000-40,000 ft. in altitude.

Related Projects/Activities:

- The NOAA Profiler is functionally similar to this system. The Profiler operates at microwave frequencies while the Doppler Lidar operates in the visible range.
- Observations from NASA's Upper Atmospheric Winds from Satellites program could be combined with Doppler Lidar measurements to provide complementary data sets.

SPECIALIZED PROGRAMS

- The National Stormscale Operational and Research Meteorology Program (p. 8-49)
- Icing programs
  - The National Aircraft Icing Program (p. 8-51)
  - Icing Forecasts (p. 8-53)
  - Aircraft Icing Technology (p. 8-54)
- Lightning programs
  - Lightning Location System (p. 8-55)
  - Satellite Lightning Detection Sensor (p. 8-56)
  - Characteristics of Aircraft Lightning Strikes (p. 8-57)

Project: The National Stormscale Operational and Research Meteorology Program

Agency: University Corporation for Atmospheric Research

Purpose: To develop the capability for observing and predicting small-scale weather phenomena with the accuracy and reliability necessary to protect the public, serve the national economy, and meet defense requirements.

Approach: A two-stream Stormscale Operational and Research Meteorology program has been established. The STORM operations program will deploy the technology required to observe, analyze, predict, and disseminate small-scale weather information. It will also train forecasters in the use of new predictive techniques. The research program will ensure that the new-generation, high-technology operational system will be used to gain the optimum advantage.

The program will involve three phases. Phase I will involve detailed planning, theoretical and assessment studies based on existing data and some limited new field work. In Phase II major new components of a warning system will be placed in operation, and extensive multiscale field programs conducted. Phase III will include the design and implementation of further improvements in the warning system and improved research using data acquired during the major field programs of Phase II. Phase III will also include a major effort to transfer research results into operational use. Three major field experiments are tentatively planned for the program, one in each of the Central, Eastern and Western portions of the United States.

At least seven Federal agencies or departments are expected to be involved in the program:

Department of Commerce/NOAA
Department of Defense/Navy, Air Force and Army
Department of Interior/Bureau of Reclamation
Department of Transportation/FAA
Environmental Protection Agency
National Aeronautics and Space Administration
National Science Foundation

Related Programs/Activities:

- Next Generation Weather Radar will provide Doppler radar capability for the program.
- Satellite data will be provided by Geostationary Operational Environmental Satellites.
- NWS and FAA automated systems will provide surface observation capabilities.
- NWS operational and prototype equipment will provide automated weather information system capabilities.

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Project: The National Aircraft Icing Program

Agency: DOC/NOAA/Federal Coordinator for Meteorological Services and Supporting Research, DoD, DOT, NASA and NSF

Purpose: To define and oversee a joint program for the coordination of aircraft icing activities of the member agencies that should meet their common operational requirements as well as those unique requirements of each agency.

Approach: A National Aircraft Icing Program Council has been established with representatives from the Departments of Commerce, Defense and Transportation; the National Aeronautics and Space Administration, the National Science Foundation; and the Office of the Federal Coordinator for Meteorology. The goals of the Program are:

- Coordinate and facilitate the development of a National Aircraft Icing Plan that meets the common requirements of the agencies, has the flexibility to accept added features needed to meet the unique requirements of the involved agencies, and is kept current through periodic updates.

- Oversee and coordinate individual agency and multiagency activities to implement a National Aircraft Icing Plan.

The planning Council will facilitate and coordinate policy development, as well as planning and implementation for the following activities: facility establishment and usage, equipment acquisition, research development, and procedures related to aircraft icing detection, forecasting and certification. Implicit in this effort is the need to ensure that aircraft icing definitions have the same meaning to users, irrespective of the agency making them.

Related Projects/Activities:

- USAF - The Air Force has several projects in the icing area including:

    - Precipitation and Soil Moisture Mapping

    - Defining icing potential with passive microwave radiometry

  - Improved forecasting of engine/aircraft icing

- NASA - a multi-faceted program for studying aircraft icing, principally at the Lewis Research Center in Cleveland, OH.

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Project: Icing Forecasts

Agency: DoD/U.S. Air Force

Purpose: To improve engine/aircraft icing forecasts

Approach: The Air Force has renewed efforts to improve understanding of aircraft icing, and is developing icing climatologies from standard meteorological data and Defense Meteorological Satellite Program-derived cloud data.

In another effort, ground-based passive microwave radiometry techniques will be tested to evaluate their potential for defining zones of aircraft icing potential.

Icing potential is related to liquid water content of clouds, and a project using the DMSP SSM/I (microwave imagery data) has a goal of providing worldwide data on cloud liquid water content.

Related Projects/Activities:

- Office of the Federal Coordinator - The National Icing Plan
- NASA - technology base for aircraft icing

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Project: Aircraft Icing Technology

Agency: NASA

Purpose: To improve aircraft operations during icing conditions through technological advances.

Approach: A multi-faceted aircraft icing technology program is underway at the NASA Lewis Research Center in Cleveland, OH. Projects include:

- Establishment of a technology base for advanced airfoils, materials, and propulsion systems
- Reduction in development and certification time and costs for all classes of aircraft
- Establishment of safe limits for aircraft operations through a flight research program and experimental testing in an icing facility
- Development of low cost, lightweight, low energy and low maintenance aircraft icing protection systems
- Development of instruments to detect and measure icing parameters

Related Projects/Activities:

- Office of the Federal Coordinator for Meteorology - The National Aircraft Icing Plan
- USAF - Improved forecasting of aircraft icing

Project: Lightning Location System

Agency: DoD/U.S. Navy

Purpose: To develop a system for detecting and positioning lightning strokes at mesoscale ranges.

Approach: The Navy is proceeding with a program to install commercial lightning tracking systems to meet Navy requirements. The effort has been jointly conducted by the Office of Naval Research and the Naval Air Systems Command. A test and evaluation system has been installed at Cecil Field, Jacksonville, Florida. This configuration consists of four antennas at the corners of an approximate one hundred mile square, a master station, and a programmable communications and data processing terminal. Each remote antenna/receiver detects lightning stroke electromagnetic pulses over a wideband range. Each receiver performs preliminary wave form analysis and transmits pertinent data to the master station where strike location is determined by time of arrival techniques. System accuracy is less than one mile within the antenna site boundaries.

In addition to the Lightning Location System being developed by the U.S. Navy, the State University of New York (SUNY) has developed a detection and tracking system which covers the northeastern and middle atlantic states under a grant from NSF. Display outputs from this system are used by the NWS office in Albany, New York and a demonstration project at the ARTCC in Leesburg, Virginia.

Related Projects/Activities:

- NASA is studying the feasibility of detecting lightning strokes from geosynchronous altitude.

Project: Satellite Lightning Detection Sensor

Agency: NASA

Purpose: To develop a sensor for detection and location of lightning strikes from geosynchronous satellites.

Approach: NASA is studying the feasibility of a sensor which will be able to map any lightning stroke within its effective field of view from geosynchronous satellite altitudes. This sensor will have the capability of detecting cloud-to-ground strokes, and locating them with an accuracy of 10 km anywhere within the field of view (virtually the entire disc of the earth). The sensor should provide new scientific insights into global electrodynamics, the relationship to various weather phenomena, and the frequency and global distribution of lightning. Design studies for a sensor with mapping capabilities are underway. A space qualified sensor could be deployed by the late 1980's.

Related Projects/Activities:

The Navy's Lightning Position and Tracking System could provide a number of "ground truth" locations for satellite data verification.

Project: Characteristics of Aircraft Lightning Strikes

Agency: NASA

Purpose: To develop a data base of the characteristics of aircraft lightning strikes.

Approach: NASA lightning program is to measure the characteristics of direct lightning strikes at aircraft operating altitudes; and to develop a data base of lightning strike characteristics suitable for establishing of design criteria for aircraft with extensive composite structure and digital control systems.

METEOROLOGICAL MODELING PROGRAMS

- Meteorological Modeling and Techniques Development (p. 8-61)
- Macroscale Numerical Modeling (p. 8-63)
- Numerical Modeling and Techniques Development (p. 8-64)
- Numerical Model of Convective Weather (p. 8-65)
- Comprehensive Mesoscale Numerical Model (p. 8-66)
- Mesoscale Analysis and Modeling Research (p. 8-67)

__Project__: Meteorological Modeling and Techniques Development (Navy)

__Agency__: DoD/U.S. Navy

__Purpose__: To develop meteorological models for use at the Fleet Numerical Oceanography Center and to provide the base for other operational systems to be tested and implemented.

__Approach__: The objectives of this work area are: 1) the development of numerical techniques, models, and software for analysis and prediction of all scales of atmospheric phenomena for use at the Fleet Numerical Oceanography Center; 2) the development of synoptic and/or statistical weather forecast techniques for use by the Fleet meteorologists, primarily on-site; 3) the investigation and/or development of cost-effective technological options for obtaining accurate and timely measurements of the natural environment needed as inputs to assess and/or predict the performance of weapons system over the marine environments; and 4) the coordination with weapons system developments in concept phases to establish environmental support requirements.

The numerical modeling work provides the base for the operational systems to be tested and implemented at the Fleet Numerical Oceanography Center. The exploratory development includes several components: (1) nested regional model development; (2) tropical cyclone dynamic predictions; (3) data assimilation system development; (4) global atmospheric model development; (5) stratospheric global model development; (6) marine boundary layer model development; and (7) modeling of unique atmospheric parameters.

The synoptic and statistical work includes: (1) tropical forecasting; (2) statistical tropical cyclone forecast aids; (3) short-range statistical forecasting; (4) marine fog forecasting; and (5) model output statistics for forecasting air-ocean parameters.

The investigations of measurement technology include examination of existing, as well as newly developed, instrumentation for suitability of operation in existing and future fleet airborne and sea-based vehicles.

Related Projects/Activities:

- NOAA Macroscale Modeling - NOAA's modeling efforts at The Geophysical Fluid Dynamics Laboratory and National Meteorological Center have basic goals similar to those of the Navy's modeling efforts.

Project: Macroscale Numerical Modeling (NOAA)

Agency: DOC/NOAA

Purpose: To develop numerical prediction models based on the state-of-the-art techniques.

Approach: The National Weather Service conducts research and development in numerical prediction to improve the general forecast and warning services by placing the analysis and prediction system on a stronger scientific basis. Numerical prediction models that simulate atmospheric and hydrologic processes are constantly worked on, and better computer techniques to solve the underlying equations are developed. These efforts should result in better forecasts of upper level winds and temperatures for aviation, and better guidance for other forecast products.

NOAA's Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton, New Jersey is responsible for the research and long-term development of new numerical prediction models from a strictly scientific standpoint. NOAA's National Meteorological Center in Suitland, MD is responsible for the development of operational numerical prediction models based on the results of GFDL efforts or other state-of-the-art advances.

Related Projects/Activities:

- The Navy's modeling efforts at the Fleet Numerical Oceanography Center have basic goals similar to those of NOAA's numerical prediction efforts.

Project: Numerical Modeling and Techniques Development (Air Force)

Agency: DoD/Air Force Geophysics Laboratory

Purpose: To develop numerical prediction models and meteorological techniques for application to Air Force operations.

Approach: Numerical models are being developed to improve the current state-of-the-art for predicting winds, temperatures, and clouds. Results of these efforts are expected in 1985.

In the mesoscale weather forecasting area, models are under development for short-range (0-6 hours) prediction of cloud ceiling and visibility. Also, a cloud forecast and a coastal fog model are being developed for minicomputer application. Deliverables are expected in the FY 1985-1987 time period.

Other technique development efforts are aimed at automated Terminal Forecasts: 1) based on forecast algorithms; and 2) based on climatology. The climatology efforts are twofold. The first is aimed at the development of a climatology model based on geophysical influences (such as proximity to water). The other effort is directed toward developing an improved statistical model to rapidly compute joint probability of ceiling and visibility at a station.

The work will also include development of joint probabilities of ceilings and visibilities at two stations as a function of time and geographical proximity.

Project: Numerical Model of Convective Weather

Agency: DOC/NOAA/National Severe Storms Laboratory

Purpose: To develop a comprehensive numerical model of convective weather.

Approach: The parameters of convective storm development and intensification are being identified through the incorporation of observations from a dual Doppler radar system, conventional radar, a tall meteorological tower, a lightning location and characterization system, instrumented aircraft, and an automated surface network. The National Severe Storms Laboratory is preparing a three-dimensional, time-dependent numerical model of convective weather which includes the ice phase and rudimentary electrical processes as basic resources for relating thunderstorm data to natural processes of storm initiation and development.

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Project: Comprehensive Mesoscale Numerical Model

Agency: DOC/NOAA/Office of Weather Research and Modification

Purpose: To develop techniques and technologies to improve short-term forecasts of significant weather events.

Approach: Through detailed case studies and regional climatologies, the Office of Weather Research and Modification has developed diagnostic tools and aids to operational forecasting for severe thunderstorms, flash floods, convective storm complexes, and downslope windstorms. Advances in numerical modeling of local weather have included simulations of air flow, clouds, and precipitation (rain and snow) in the Alsace region of France, in the islands of Hawaii, and over the mountains of the western U.S. The development of a mesoscale model, which realistically simulates the pressure perturbations generated by severe convection, is also proceeding. Improved and simplified numerical procedures will allow nesting the model in large scales so that testing with real data can be performed. Adaptation of models to special local problems such as downslope wind prediction, and streamlining them to fit into medium-sized computers for potential operational applications will be the next steps.

Project: Mesoscale Analysis and Modeling Research

Agency: NASA

Purpose: To study the synoptic to mesoscale processes which organize, initiate, and maintain severe convective storms and major winter storm systems.

Approach: Numerical simulations of specific cases are conducted at several universities under NASA sponsorship to better understand: 1) the scale interaction leading to severe storms, 2) the synergistic relationship between large-scale dynamics and physical processes in the pre-storm environment and 3) the sensitivity of the forecasts to initial state perturbations.

Mesoscale models over a large number of cases are also used to determine the utility of the models for satellite impact studies.

9. STATE AVIATION WEATHER PROGRAMS

State Aviation Weather Activities

It is essential that the Federal Aviation Administration recognize and support the aviation weather activities of the various State aviation organizations and departments and their respective local municipalities. There are a number of active State aviation weather programs which require the support of the Federal agencies and should be incorporated into Federal programs to some degree.

A mechanism exists to provide this needed support through the Airport and Airway Improvement Act of 1982. The FAA's Associate Administrator for Airports is responsible for the management and administration of the Airport Improvement Program (AIP) which authorizes Federal grants for the purchase and installation of non-Federal aviation related weather reporting equipment. To implement this mechanism, the Office of Airport Standards, the Office of Airport Planning and Programming, and the Weather Coordination Program Office will initiate an agency review to consider policies, procedures, standards, and criteria for the selection, approval, and funding under AIP of aviation-related weather reporting equipment and systems and for assuring their effective use and operation within the National Airspace System. State and locally-operated public use airports are a key element of the National Airspace System and full consideration of their requirements for aviation weather support and assistance through the Airport Improvement Program will be a continuing factor in the development of the FAA Aviation Weather System.

Currently, a number of States have active, ongoing aviation weather programs and are planning the expansion and improvement of their aviation weather support for airports within their jurisdiction. These activities will be continuously monitored at the Federal level, and assistance of the aviation weather-oriented Federal agencies extended where appropriate. Future revisions of this Plan will provide cognizance of and support for State aviation weather programs. State Aviation Departments have and will continue to be encouraged to provide input on State sponsored aviation weather programs and their requirements.

Current State Aviation Weather Programs

Maryland

The State of Maryland is currently developing an aviation weather information system which is to be implemented in 1985. The Administration, through the Office of General Aviation, will place computer terminals in five airports throughout the State, which can be used to access several weather data bases. The program is designed to assist pilots in obtaining weather information and flight planning. The program will expand over a period of time to include 29 locations.

Minnesota

The Minnesota State Aviation Department has an active and well funded aviation weather program. The State provides a toll free 800 number for weather briefings available to the pilots statewide. The Department has established a network of 50 computer terminals at 43 airports where pilots can obtain comprehensive weather briefings, including the weather graphics and computer-generated flight plans. An option is available to permit individuals, who own terminals, to subscribe to this 24-hour service. Currently, at several selected locations, color weather radar displays are available for flight planning, and plans are underway for expanding this service.

Montana

The State of Montana provides toll-free telephone service to pilots for flight plan filing and weather briefings.

Nebraska

The State of Nebraska has an ongoing program, officially designated the Shared Weather Observation Program, commonly known as "the Nebraska Agreement". This cooperative agreement is between the National Weather Service, the Federal Aviation Administration, and the State of Nebraska, Department of Aeronautics. Eighteen observation sites have been established across the State, and each provides a minimum of 13 observations daily. Each party to the agreement provides 25 percent of the costs for labor with the local community involved providing 25 percent. Also shared, but not necessarily equally, are the physical items required by the Program. In establishing the agreement, the National Weather Service assumed responsibility for the observation equipment and related expendable supplies; the FAA provides all necessary communications and enters the observations into the national weather network through the Flight Service Station system; the State installs and maintains the equipment, supervises the operation of the sites, and conducts observer training. Additionally, the local community furnishes the observation site, personnel staffing, utilities, and office supplies. This agreement was effective on January 1, 1980, and has been extremely successful in providing more and better quality observations at lower cost. The State of Nebraska is also currently developing a capability to provide direct user access to aviation weather by integrating FAA weather data and an existing computer subscription system at the University of Nebraska. The project would make aviation weather information available to subscribers through personal computers.

New York

In 1985, the New York State Department of Transportation initiated a "New York State Facilities and Equipment Plan Study". This study will lead to a recommendation of a state/local program for terminal navigational aids, visual landing aids, and real-time weather reporting systems to serve the airports in the State Airport System Plan.

North Carolina

Information provided through the National Association of State Aviation Organizations indicates that the State of North Carolina has a limited number of automatic reporting systems in operation.

North Dakota

The State of North Dakota also operates a limited number of automatic reporting systems.

Oregon

The State of Oregon provides a toll-free telephone service to pilots for flight plan filing and weather briefings. The State also provides equipment and training for weather observations at several airports, and operates five Supplementary Aviation Weather Reporting Stations for the national system.

Pennsylvania

The Pennsylvania Department of Transportation is in the process of developing a plan to guide the implementation of automated weather reporting systems at airports across the Commonwealth.

Virginia

In 1983, the Commonwealth of Virginia developed and published the "Virginia Facilities and Equipment Plan". Discussed in Section V of this comprehensive Plan is their program for an Automated Weather Reporting System. Two types of systems are planned: a basic model and an enhanced model. The basic model will provide altimeter setting, wind speed and direction, wind variability, temperature, and dew point. The enhanced model will add cloud height and visibility. In the longer term wind shear sensors, currently under development, may be incorporated in the system. The plan identifies 26 locations, 7 basic and 19 enhanced, to be in operation by 1990. Currently, there are five basic and one enhanced (Lynchburg) systems in service.

Washington

The State of Washington, Division of Aeronautics, has an ongoing program to conduct weather training seminars for pilots throughout the State.

Wisconsin

In early 1984, the State of Wisconsin installed weather computer terminals at 18 airports where pilots can obtain weather charts, comprehensive weather data and computer--generated flight plans. Residents also have the option to subscribe to the 24-hour service through their home computer. In addition, the State Aeronautics Bureau has held aviation weather classes through the Statewide Extension Education Network which have incorporated computer access as well as a broad variety of local weather interest areas.

10. CONCLUSIONS AND BENEFITS

When the FAA Aviation Weather System has been fully implemented, pilots, controllers, and specialists will have at their disposal the finest system for collecting, processing, communicating, and displaying weather observations and weather forecasts that modern technology can provide.

The entire country will be covered by a network of radars designed specifically to provide meteorological data. These data will be precipitation intensity, radial velocity, and radial velocity spectrum width, which will be used to generate the needed aviation weather products. In the future, selected major airports with high traffic density and a high frequency occurrence of thunderstorms may be provided with a Terminal Doppler Weather Radar optimized to detect wind shear, microbursts, and turbulence.

Every airport/heliport with an instrument approach, if qualified in accordance with Airway Planning Standards, will have an Automated Weather Observing System. Runways at airports will be equipped with sensors, and methods will be developed to transmit runway conditions (wet, flooded, slush, snow, or ice) to airport operations/maintenance personnel and to pilots.

All Area Control Facilities will have a Central Weather Processor which will support the Center Weather Service Unit, the Area Control Facility operations, and Air Traffic Control Towers. A Flight Service Data Processing System will provide weather information to the Automated Flight Service Stations within the ACF's area of control responsibility.

Two National Aviation Weather Processing Facilities will provide the communications interface between the National Weather Service and the FAA's National Airspace System.

On the ground, pilots will have access to a broad spectrum of weather products through the Direct User Access Terminals to the AFSSs. These products will be available in alphanumerics, graphics, or as voice messages with and without the assistance of an FSS specialist.

Broadcasts of routine as well as hazardous weather conditions such as HIWAS, high altitude EFAS, and automatically and updated voice broadcasts will be made available to the airborne

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pilots. In addition, airborne pilots will have direct access to weather products using the new Mode "S" data link for alphanumerics or graphics, or through VHF radio for voice messages.

Air Traffic controllers will be provided with special displays of severe and hazardous weather. These weather displays will be augmented by annotations from the ACF's Center Weather Service Unit. In addition, the Center Weather Service Unit will be available for consultation by the ACF flow controller.

Winds aloft forecasts will have improved dramatically with the introduction of modern remote sensors such as the microwave Doppler radar (Profiler). The Profiler will provide essentially continuous observations of winds aloft replacing the 12-hour rawinsonde observations that are in use today.

Collection and communication of weather observations and forecasts will be at high speed with the establishment of the National Airspace Data Interchange Network.

BENEFITS

The benefits to be derived from the implementation of the FAA Aviation Weather System Plan will impact every segment of the aviation industry.

Pilots will have access to more accurate descriptions of storm systems as well as more accurate forecasts of the location, evolution, and trajectory of these storm systems. This overall improvement in observations, descriptions and forecasts will allow pilots and other NAS users to more efficiently use the Nation's airspace. The net result will be savings in time, fuel, and money. There will also be a significant increase in the safety of flight operations when continuous real-time, hazardous weather information is available to pilots. As knowledge of the weather conditions improves, and the pilots' confidence in this knowledge grows, the number of weather-caused or weather-related accidents should decrease significantly. Passengers will also benefit from the increased safety and the associated increase in comfort that results from the application of better knowledge and understanding of weather conditions particularly related to weather hazards.

Controllers and Flight Service Station specialists will benefit from the improvements in quality, accuracy, and timeliness, and from the unambiguous nature of the displays of severe and hazardous weather that will be available to them. Controller

benefits will be derived mainly from the minimization of their time spent in interpreting and disseminating severe and hazardous weather information. Strategic planning will also become more precise as forecasts improve. Flight Service Station specialists will benefit primarily from the elimination of time spent in handling paper, making weather observations, and providing routine weather information. Through the use of interactive terminals having access to accurate forecasts in real-time, and severe and hazardous weather data, the specialists will be able to provide accurate and meaningful flight planning information as well as hazardous weather avoidance assistance to pilots. The net benefits will be in savings of time, money, and fuel. The FAA itself will benefit from a more efficient use of its personnel, which will result in a reduction in operating staff and, subsequently, operating economics.

The National Weather Service and the National Airspace System will benefit from an order of magnitude increase in observations provided by the Automated Weather Observing Systems, the Next Generation Weather Radar Network, and the operation of automated workstations for the meteorologists at every Area Control Facility. Benefits will be derived from the increase in quality and quantity of data to the National Meteorological Center for input to the numerical models that generate the bulk of the weather products.

11. USER REVIEW, AND FAA RESPONSE

The second edition of the Aviation Weather System Plan received generally favorable review by the users, and the majority of the comments were editorial in nature. The non-editorial comments received are presented in this section. FAA's response to specific comments follow each reviewer comment.

Ohio University, Avionics Engineering Center

Comment: Presentation--The indication is that the presentations are principally for the briefer or controller. The pilot has no visuals generally available.

FAA Response: Comment accepted and paragraph on Presentation has been rewritten. Comment that "The pilot has no visuals generally available" is true and a recognized deficiency in the system. Implementation of pilot self-briefing through Direct User Access Terminals and cockpit displays of hazardous weather contours via the Mode S data link will alleviate this situation.

Comment: Weather Information Requirements--The pilot in flight is virtually ignored. Note is made that the ATC controllers, FSS specialists, and meteorologists are well identified, however.

FAA Response: Comment accepted: terminology changed from "Airspace User Requirements" to "Pilot Requirements" and introductory remarks altered for clarity. Pages 3-1 and 3-2 solely address pilot requirements which are further summarized in Table 3-1, Page 3-5.

Comment: En route pilots are identified in the drawing but the link of graphics weather data does not recognize the requirements for handling the graphics. Mode S can handle practically only the most elementary type of graphics on a request and reply basis.

FAA Response: Comment not accepted for a change to the Plan. Mode S will be able to supply needed weather data to the pilots in-flight.

The FAA plans to provide hazardous weather contours to the cockpit via Mode S data link. These contours will be oriented to the nose of the aircraft, screened by experienced meteorologists and, where possible, will be based upon data from more than one weather radar. This technique, coupled with the next generation Doppler weather radars, will ensure that the pilots receive a true picture of the hazardous weather conditions oriented to the aircraft's position and direction of flight.

Comment: It is not clear how the pilot in-flight will get the full benefit of the NEXRAD. Data handling indicated by the plan is not sufficient for the ground to air link.

Mode S is identified for providing weather information directly to the cockpit. The system is known to be deficient in that it cannot handle the quantity of data required for desirable graphics presentation.

Note should be made that the Mode S is not capable of handling the quantity of data that is needed. NEXRAD data, for example, cannot be handled.

FAA Response: Technical arguments concerning Mode S capabilities have been on-going since the inception of the concept. FAA development engineers and their consultants find that the Mode S data link will handle the up-linking of hazardous weather contours to pilots in flight. These contours will be developed from NEXRAD data as well as from other data sources. A second opinion on the capability of Mode S will be obtained when the FAA's Systems Engineering and Integration Contractor, Martin Marietta, completes the examination of the interoperability and interfaces of the National Airspace System. This examination will identify specific areas where there could be shortfalls in service to the airspace users.

Comment: Icing is a crucial item for general aviation in particular. Knowledge of it is a key to safe, reliable flight operations in much of the U.S. in the fall, spring and winter. Insufficient attention is given to this problem. It is recommended that development and implementation of a solid-state, cloud-top height determinator be accomplished. The abandonment of the vacuum tube models has decreased the availability of this valuable information to pilots.

FAA Response: FAA agrees that more attention needs to be applied to the aircraft icing problem and it has already taken two major steps to address this issue. The FAA in 1985 asked the Federal Coordinator for Meteorological Services and

Supporting Research to form a panel of high level government managers and with their guidance develop a National Aircraft Icing Plan. This plan will identify the work that needs to be done and who should be doing it. It will address all aspects of the icing problem from forecasting to on-board equipment and cover all classes of aircraft and rotorcraft.

The second action taken by FAA was the initiation of the Aviation Weather Forecasting Task Force under the leadership of Dr. John McCarthy of the National Center for Atmospheric Research. This group is looking at all aviation forecast products to determine what near term improvements can be made to these products.

Longer term actions which will enhance our capability to forecast for and to identify areas of icing are the completion of the NEXRAD program and implementation of the vertical Profiler network.

Comments by the State of Idaho - Transportation Department

Our concerns here in Idaho are basically the same as those expressed by individuals in other parts of the country. Namely:

1. *Inadequate weather information. We have few reporting points in the Northwest and with the closing of FAA and NWS facilities, or with only part-time operations, the capability has deteriorated to the point where it is non-existent at some times, and some places. The situation is so bad that there are times during actual IFR weather when there are no legal alternate airfields available within reach of the fuel capability of most general aviation airports and Part 135 airplanes.*

2. *Incomplete and inaccurate weather data. The speed of the weather transmission equipment plus the confusion that seems to abound between who is doing what leaves the pilot in a quandary as to really what kind of weather to expect. It is difficult in most places to talk to NWS forecaster and it would appear that FAA Flight Service Station personnel have been instructed to offer no information that requires value judgment on their parts, so all that remains is what can be extracted from the computer - if it is not down. Very few people ever question the source of the weather data or just how few reporting stations make up the field from which the data is drawn. Experience demonstrates time and again that the weather is not as forecasted.*

It is on this backdrop that we respond to the second edition of the Aviation Weather System Plan. Perhaps as users, we should take the position that we don't care what the process is as long as the end product is usable, accurate, and timely. We are concerned though and we feel that we at the state and local level have as much right to form our airspace system as the federal government does. Our concerns are in major areas:

1. Adequacy of Plan

The adequacy of the Plan appears to be in doubt. The needs of many general aviation and all Part 135 operators are simply ignored with respect to the provisions of Par 135.213, Par (b), Part 135, Federal Aviation Regulations. There seems to be no provision presented in the Plan which will solve the problem of Part 135 IFR operations into airports where weather reports are based on AWOS. It is suggested that reality of this problem not be put on the shelf as if the need for GA/Part 135 IFR operations into certain airports does not exist. Also, the IFR alternate requirements will probably be of greater concern. Without observations the leg lengths to alternates will, in many cases, be longer in order to reach most airports with a valid Terminal Forecast. The problem for Part 135 operations will then be compounded due to their limited fuel capacities combined with longer leg lengths to reach "legal" alternates.

FAA Response:

The FAA believes that the Automated Weather Observing System will meet the requirements of FAR Part 135.213 operations. However, it was not directly addressed in the discussion of AWOS. Valid forecasts can be made from AWOS observations. Today there are forecasts made for AUTOB stations which frequently have less capability than that planned for AWOS. We see AWOS meeting both the observation and forecast needs of Part 135 operators.

2. Thoroughness of Plan

The Plan appears to be a very thorough overview of what the FAA should be doing today in its Flight Service Stations, Control Towers, and Air Route Traffic Control Centers, but for a myriad of reasons do not quite get the task accomplished.

We have already mentioned the FSS. Most of them really appear to be so concerned about incurring some liability in case of an *accident that about the best they can do is read the hourly sequence, read a route synopsis of what may be out there. Towers will give the weather when asked for it and provide wind information when asked. Centers are generally too busy to say much about weather even to accommodate a pilot request. Also, Center radars are look angle adjusted for aircraft control and in our opinion adjustments to accommodate weather will compromise both aircraft control and weather acquisition. Certainly, we recognize that these various organizations need to be cognizant of developing weather. We absolutely agree, especially that FSS personnel should be very proficient in weather systems analysis if they are to give adequate briefings. Of course, if they are not expected to give briefings then ------.*

Further, the FAA's concept of "Reliever" airports will, in many cases, be invalidated due to the absence of a valid forecast which will enable general aviation/Part 135 operators to use them.

FAA Response:

This comment seems to be directed at operations and not planning. In other words, the Plan seems complete, but it is not being done that way in the field. Flight service specialists are expected to provide briefings based upon National Weather Service forecasts and warnings, weather radar and surface observations and pilot reports. Those specialists are not expected to be proficient in weather systems analysis, that is the job of the National Weather Service meteorologists.

3. *Unrealistic Expectations of FAA*

It seems unreasonable and unrealistic for this plan to be thrust upon anyone as a partially funded package. For instance, if the states are expected to acquire AWOS equipment with AIP Funding some of them will:

- *a. Have inadequate funding.*
- *b. Will be unable to maintain/improve/develop basic airport system needs.*

In short, we are not only handed the burden, but also expected to shoulder the load to a questionable "destination" without the realistic capability to do it.

It makes more sense to us that the FAA would devote more time and energy to the regulating of aviation resources in this *nation, and to the promotion of aviation safety; and that the NWS, where the forecasters, meteorologists and weather analysis experts are already in place, would be more fully funded, charged with the responsibility for providing aviation weather information to the FAA for dissemination. It appears to us that the FAA is planning to develop their own weather service along side of the NWS. This does not seem justifiable nor cost effective to us. The warm, unstable air mass that produces thunderstorms and creates flying hazards also generates tornados that destroy towns and hail that damages crops. A meteorologist does not have to also be an aviator to interpret weather for aircraft use. Why can't the NWS gather and analyze the data and the FAA spend their time, money, and energy obtaining the fastest real time accurate information from them. It is the pilot who makes the final decision - but the pilot must have accurate timely information to make accurate timely decisions.*

FAA Response:

We do not think that the Aviation Weather System Plan hands the burden of providing weather observations to the States. It does describe the federal government's intentions in the area of aviation weather services. The FAA does intend to procure, install, and operate a relatively large number of automated surface observing systems throughout the nation. The National Weather Service will also be installing similar systems throughout the nation at airports where they are responsible for taking weather observations. The distribution of the FAA systems will be largely based on benefit/cost analysis. These analyses will give additional credit for remote locations where air transportation plays a more significant role in the daily lives of our citizens. Airports which do not meet the criteria for Federal installation and operation of Automated Weather Observing Systems may be eligible for Airport Improvement Program funding.

The FAA and the National Weather Service do share the responsibility for aviation weather services in the manner suggested. The National Weather Service is responsible for providing basic weather information, aviation forecasts, and warnings. The FAA is responsible for disseminating the information. However, both share the responsibility for taking observations with the military services. The FAA is not trying to increase its role in aviation weather, it is trying to obtain and/or provide the information pilots need to operate safely and economically. The FAA has only a few meteorologists on its rolls and they are employed in system development. We look to the National Weather Service to provide the needed products and they are funded directly from the Aviation Trust Fund for this support. The programs the FAA is pursuing are designed to move the information received from the National Weather Service more quickly, to package the information in the most usable manner for aviation and to display it to four distinct user groups, pilots, controllers, flight service specialists, and meteorologists who are assigned to FAA Air Route Traffic Control Centers.

4. *Duplication of Effort Among Agencies:*

It seems incongruous that the National Weather Service, Department of Defense, National Oceanic and Atmospheric Administration, Federal Aviation Administration, Department of Agriculture, Department of Interior, Treasury Department, National Science Foundation and National Aeronautics and Space Administration and maybe several more Governmental entities are all involved in collecting and analyzing weather data. Even to a layman this can hardly be judged cost effective. It seems equally inconceivable that the FAA can, as this study seems to indicate, take it upon itself to build up another weather reporting and analysis system complete with meteorologist to the exclusion of the National Weather Service. It would appear to us users on the outside that this is a race for territory rather than an effort to most effectively solve the problems that the aviation fraternity is plagued with. An example that illustrates this point has to do with the proposed Automated Weather Observing System. While the FAA is pressing blithly forward spending millions of dollars on proposed systems, the Bureau of Land Management already has dozens of remote automatic weather observation systems in the field.

These stations are able to accommodate sensors that could measure any information required. These sensors could be purchased and installed for several hundred dollars each. The existing BLM system is already tied into a central computer by satellite and for less than $200,000 it could be tied into the NWS computer also thus providing an automatic system for less than a million dollars that has already been proven operable and field checked. We fail to understand why these innovative opportunities continue to pass by while the Aviation Weather System continues to deteriorate.

FAA Response:

We agree with the concerns expressed concerning duplication. Several years ago, the FAA initiated a program through the Office of the Federal Coordinator for Meteorological Services and Supporting Research to develop a National Aviation Surface Observation Plan. The plan would identify all of the existing observation sites. The various agencies working together would identify those sites which have joint use potential and the changes required to achieve this potential. This effort is approximately 50 percent completed. There is certain weather information that is required to operate into and out of airports. This information is required from the immediate location of the airport. There are very few of the Bureau of Land Management sites that would be beneficial for airport operations. Aviation's requirements for visibility, present weather, and cloud cover and height information make automatic sensing more difficult to accomplish and also more expensive. Other weather information from remote locations will, of course, benefit the aviation forecaster. This is particularly true of the lightning detection system the BLM operates. A coordinated effort is underway to establish a national lightning detection network that will make use of all the systems presently in operation.

As to FAA's grab for territory, we offer the following information: FAA currently takes approximately 383 surface observations for aviation and the National Weather Service takes approximately 250 aviation surface observations. This is a carry over from the 1940's and 1950's, when both agencies were in the Department of Commerce and efforts were made to reduce manpower requirements through joint-use wherever possible. Consideration is currently being given to put the surface observation program back in the National Weather Service.

APPENDIX A

AIRSPACE USER RECOMMENDATIONS

The following information was presented in the first edition of this plan as Chapter 3. The majority of the recommendations, many of which were procedural in nature, have been acted upon, or are being addressed in current programs. A limited number of recommendations cannot be immediately achieved and action is contingent upon the results of future development programs. All of the airspace user recommendations have been retained in this Appendix, and represent background information and a point of reference for the reader.

Several review committees representing airspace user organizations--Air Line Pilots Association (ALPA), Aircraft Owners and Pilots Association (AOPA), Air Transport Association (ATA), Helicopter Association International (HAI), National Business Aircraft Association (NBAA), General Aviation Manufacturers Association (GAMA) and U.S. Government agencies (NOAA, FAA, DoD and NASA)--have expressed user weather needs through various recommendations. Some of the representatives of these organizations and the National Transportation Safety Board (NTSB) have also made suggestions to the Congressional Committee on Science and Technology for improving the quality of aviation weather information. The recommendations made by individual committees and members are listed here. These recommendations are also summarized into two specific categories: 1) procedural; and 2) those requiring capital investment. A discussion from the user perspective of major system areas for enhancement is also included.

Specific Recommendations

National Airspace Review Committee Recommendations

In 1982, the Task Group (TG1-4) of the National Airspace Review (NAR) Committee was assigned to review the current weather data collection and dissemination processes, products, and programs to enhance real-time availability of information to all segments of the aviation community. The group made 26 recommendations for near-term improvements to the existing weather system capabilities. These recommendations are:

1. Designate a position at the highest FAA staff level to manage and coordinate aviation weather services.

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2. NWS and FAA should undertake a program to provide Automated Weather Observing System to support the instrument approaches at public use airports with standard instrument approach procedures.

3. Redefine CWSU functions with emphasis on improving dissemination of real-time weather information to the airspace users.

4. Revise the FAA/NOAA Memorandum of Agreement to reflect the currency, definition, direction, and leadership that must be placed on aviation weather services.

5. Maintain the current number and quality of aviation weather surface observations.

6. Make weather briefing documents consistent with the existing policy and procedures.

7. NWS should continue operation of the National Facsimile Circuit until replaced by an alternative system. The Automation of Field Operations and Services (AFOS) implementation should provide additional time slots on NAFAX for transmission of surface analysis, radar summary and significant weather prognosis charts.

8. Provide complete NWS radar summary charts.

9. Prepare Terminal Forecasts consisting of a 12-hour specific forecast and a general 12-hour outlook to be transmitted at 6-hour intervals.

10. Improve upper winds measurements and forecasts by increasing the frequency of rawinsonde observations, and acquiring data from other sources, such as Profilers.

11. Implement color Radar Remote Weather Display System at all Flight Service Stations having Weather Bureau Remote Radar (WBRR) system. Continue WBRR network until RRWDS is fully implemented.

12. Revise the Airman's Information Manual (AIM) to define expected and requested pilot briefing items.

13. Add dew point data on ATIS.

14. Replace Service A teletypewriter equipment and increase WMSC capacity.

15. Increase support for the Weather public television program (for expanded coverage and additional broadcasts).

16. Provide a CWSU communication system, for timely dissemination of weather information to sectors and other air traffic field facilities.

17. Address AFOS, National Meteorological Center, Gateway and FAA weather systems interfaces to prevent loss of data.

18. Provide continuous broadcasts of real-time hazardous weather data. The various programs under development should not compete in the use of VORs.

19. Use concise format and plain language to present weather products.

20. Emphasize the solicitation and dissemination of terminal and en route PIREPs.

21. Provide user access to NWS ground weather radar information for display in the cockpit.

22. Provide pilot direct access to real-time weather radar network displays for preflight use.

23. Retain TWEBs until the Voice Response System is available.

24. Maximize the distribution of PIREPs. Standardize format to be used by all participants, and vest the prime responsibility for collecting and disseminating PIREPs with the FSS.

25. Include discrete high-altitude frequency spectrum and UHF in EFAS.

26. Update aviation weather knowledge requirements in Federal Aviation Regulations (FAR), Parts 61 and 141.

General Aviation Safety Panel Recommendations

A panel of 13 representatives of the general aviation community was formed in 1982 to suggest means for improving the safety of general aviation operations. The group (called the General Aviation Safety Panel chaired by J. W. Olcott) made the following recommendations for short- and long-term weather system improvements.

1. Standardize the weather minimums requirements (ceiling, visibility, distance from clouds, etc.) for uncontrolled airspace at night, to be the same as those used for controlled airspace.

2. Improve the collection and dissemination of PIREPs. Standardize the PIREP format. Designate a "Weather Observer" frequency for free exchange of PIREPs.

3. Accelerate the establishment of high-altitude EFAS with its own frequency.

4. Encourage greater use of commercially available direct-access self briefing terminals. Enable the direct-access system to accept flight plans by providing an electronic interface with the FAA's processing system.

5. Accelerate implementation of a data link capability that will provide timely weather data, in both textual and graphic form, to the pilot in flight.

6. Organize the management of FAA weather activities under the direction of one person.

Recommendations to the Congressional Subcommittees

In March and August of 1982, members of ALPA and AOPA appeared before the Congressional Committee on Science and Technology. Their testimony contained suggestions for improving the present Aviation Weather System. The following paragraphs highlight these recommendations.

ALPA Recommendations

ALPA made the following recommendations at the Congressional hearings on August 11, 1982:

1. Shorten forecast time frames.

2. Provide more frequent upper air wind data.

3. Require all FAR, Part 121 carriers to have airborne radar.

4. Provide more efficient and standardized CWSU operation.

5. Provide a high altitude EFAS Program.

6. Develop suitable wind shear detection capability.

7. Develop a capability for air carriers to receive NWS weather radar display information.

8. Improve NWS radar summary charts, and retain Azimuth/Range (AZRAN) Code.

9. Assure Congressional monitoring of the Next Generation Weather Radar program, so that interagency differences are expeditiously resolved.

10. Provide a single point of contact for weather programs to be appointed at the FAA.

11. Assure that the FAA and NWS be directed to resolve differences on roles, missions, and funding requirements.

12. ALPA (W. Melvin) proposed a scheme to limit the risks from wind shear encounters by establishing the following risk levels:

Level 1 - Meteorological conditions not conducive to wind shear (surface winds calm, less than 5 knots);

Level 2 - Some wind shears, orographic shears, nocturnal jet streams, and general gustiness (surface winds from 5 to 20 knots);

Level 3 - Wind shears approaching limit of one knot per second in horizontal plane (surface winds 20 to 40 knots);

Level 4 - Wind shears, vertical development of clouds with cell activity within 10 nmi of the airport, downburst, or microburst (surface winds exceeding 40 knots);

Level 5 - Vertical development with confirmed presence of microbursts or downbursts or cell present within 5 nmi of the airport.

Levels 1 and 2 need not be transmitted to the pilots. Levels 3 and 4 should be transmitted on ATIS as advisory information by the tower. Level 5 should generate an "automatic alert" transmitted to ARINC Communications Addressing and Reporting

System (ACARS), which would activate voice alert in the cockpit of equipped aircraft in the area.

AOPA Recommendations

Various associations, representing general aviation and air taxi/commuter airlines' interests, made the following recommendations to improve present weather services:

1. Improve short-range forecasts.

2. Improve weather communication to permit timely distribution of critical forecasts.

3. Provide self briefing capabilities and direct-access to weather products.

4. Place all weather programs under one agency.

5. Provide a 36-hour forecast to meet the round trip requirement of the General Aviation Reservation (GAR) program.

6. The following elements are recommended as minimum requirements for observations at a single site on an airport:

   a. Height of clouds (when at or below 5000 ft. AGL)
   b. Visibility or visual range
   c. Wind direction and speed
   d. Temperature
   e. Altimeter

   The following additional elements are considered desirable, but not essential:

   f. Dew point
   g. Precipitation
   h. Peak gusts
   i. Average, trend and prevailing cloud height
   j. Obstructions to vision

7. In order to compensate for a net loss of observation locations due to the closing of FSSs and NWS weather stations, weather observations can be provided at the airports by qualifying airport employees, or fixed-base operators, as Supplementary Aviation Weather Reporting

Stations observers through a joint NWS, FAA, state, and airport effort. Therefore:

a. FAA should make grants to States and other eligible bodies for purchase of weather observing equipment.

b. NWS should provide training and certification to the purchaser of weather observing equipment.

c. FAA should determine operational usefulness of cloud height and visibility measuring devices, if the measurements are taken by uncertified personnel.

ATA Recommendations

For a number of years, the ATA Meteorological Committee (formed by members from airlines, ATA, FAA, NASA, and NWS) has been meeting periodically to discuss the weather-related needs of the air carrier operators. The requirements are summarized in a series of ATA memoranda and were also expressed at an International Conference on the Aviation Weather System. These recommendations are given below.

1. Provide medium speed weather teletype circuits for the scheduled weather reports.

2. Provide high speed computer-to-computer request/reply in the event of a regular circuit failure.

3. Provide a broadcast facsimile circuit, such as DIFAX.

4. Provide access to weather satellite pictures.

5. Provide remote access to either the NWS or FAA ground-based weather radar data.

6. Provide timely receipt of useful weather radar reports.

7. Provide real-time updates of the upper winds and temperatures.

8. Retain AZRAN Code.

9. Use Limited Fine Mesh (LFM) H + 12 Forecast as an amendment to the Global Spectral H + 24.

10. Lower threshold criteria for taking special observations when RVR readings are less than 2400 ft. Revise procedures for placing these readings on Service A circuit.

11. Provide access to aviation weather data derived from new observation systems such as PROFS, MESONET, AWOS, Profilers, etc.

NBAA Recommendations

NBAA made the following recommendations for improving the availability of weather information to its members (mostly pilots operating general aviation business jets, multi-engine turbo props, and some helicopters).

1. Expedite the development of automated weather reporting capabilities, to be installed at all airports with business aircraft operations and no weather observation systems.

2. Provide weather information relating visibility within 1/2 mile and RVR within 200 ft. to the pilots.

3. Establish interchange procedures to ensure that general aviation pilots have access to all aviation weather reports on a timely basis.

4. Develop means for rapid and mass dissemination of in-flight and preflight weather data and/or briefings to general aviation pilots.

5. Develop an innovative method to provide CWSU weather information directly to the pilots.

6. Increase controller responsibilities in exchanging weather data.

7. Enable pilots to file flight plans either through the FSS, or to communicate directly with the weather and flight plan systems (i.e., WMSC or 9020).

8. The role and funding for FAA and NWS with respect to weather observations, dissemination, and forecasting should be clearly defined, and aviation weather should be given the highest priority.

NTSB Recommendations

As a result of weather-related aircraft accidents, NTSB has made a number of recommendations to the FAA and Congressional Committee on Science and Technology to improve the capabilities of the existing weather system. The recommendations are summarized below.

1. Develop accurate ground-based wind shear measuring equipment.

2. Expedite the development of integrated weather radar/ATC radar capable of providing multiple weather echo intensity levels.

3. Define and classify flight hazards associated with thunderstorms and wind gusts.

4. Provide real-time display and classification of precipitation and turbulence. Transmit the information to pilots either via controller or data link.

5. Develop a means of measuring runway braking friction and criteria on when to close a runway.

GAMA Recommendations

GAMA has proposed the following improvements to the current Aviation Weather System:

1. The FAA should assess the use of self-briefing terminals, and make this the means to disseminate weather information by the year 1985 and thereafter.

2. The ability to automatically input a flight plan to the FAA's ARTCC computer system should be provided. It should also be possible to obtain an IFR reservation through this process.

3. More effective FAA/NWS management is required to efficiently collect and disseminate PIREPs.

4. PIREPs, combined with real-time winds and temperature aloft data obtained automatically by sensors on the aircraft, the upper atmospheric radar and radiometer data, and satellite-derived information, should form the basis of a sophisticated data collection system in the future.

5. Improve EFAS with discrete high altitude frequencies, additional low altitude outlets, better PIREP data, and the ability to call up remote surface radar data from adjoining sectors.

6. Provide controllers with S-band or Doppler weather radar on a real-time basis.

7. Before HIWAS is nationally implemented, it should be ascertained that there are no frequency allocation problems which might limit the ability to disseminate voice data over either LF or VHF channels.

8. When several NOTAMs are issued, emphasize the important ones by flagging them.

Recommendations for Helicopter Operations

The basic requirements for in-land helicopter operations are essentially the same as for the general aviation pilots. For offshore operations, the following recommendations have been made to achieve the goal of improved weather services in the Gulf of Mexico. These goals are endorsed by the helicopter industry.

1. Establish aviation weather observations on as many offshore platforms as required for safe operations and improved forecasts, using SAWRS and Automated Weather Observing Systems (AWOS).

2. Establish lightning (thunderstorms) positioning and tracking systems for locating thunderstorms over all portions of the Gulf where there are helicopter operations.

3. Develop a system to provide Terminal Forecasts for platforms that have surface aviation weather observations.

4. Provide improved forecasts of thunderstorms, critical windspeeds, hurricanes, state-of-the-sea, in-flight weather (icing, turbulence) as well as ceiling, visibility, and present weather.

5. Develop a next generation communications system for the expeditious transfer of weather information to the user.

6. Ensure prompt communication of pilot reports to all users (NWS, FAA, operators).

Meteorological Workshop Recommendations

In 1981, NOAA, FAA, and NASA jointly sponsored a workshop on meteorological and environmental inputs to aviation systems. The participants from the airlines, aircraft manufacturers, research institutions, and the Government made 66 recommendations to improve routine weather forecasts, and detection/dissemination of hazardous weather both on the ground and in the cockpit. Many of these recommendations pertained exclusively to the development of better airborne/independent weather sensing capabilities (e.g., avionics) and are not included here. The recommendations specifically intended for the improvement of the Aviation Weather System are as follows.

Wind, Wind Shear, and Turbulence

1. Expand data base to improve accuracy and timeliness of winds and temperature aloft forecasts.

2. Provide frequent reporting of wind shifts in terminal areas; improve accuracy in forecasting.

3. Enhance the ATC system to inform pilots of hazardous weather areas through automated transmissions to the cockpit.

4. The FAA, NOAA, NWS, and DoD should jointly address the problem of fragmented meteorological data collection, processing, and dissemination in order to develop a system which makes effective use of perishable weather information.

5. Develop a capability for accurate four-to-six minute forecasts of wind changes which would require terminal reconfigurations or changing of runways.

6. Improve the detection and warning of wind shear by continuing the development of emerging technology for ground-based sensors.

7. Continue research on systems (airborne or ground-based) that can provide advanced or immediate alert to pilots and controllers.

8. Continue the development of Doppler radar technology, as a means of detecting the wind shear hazard.

9. Develop systems to automatically detect hazardous weather phenomena through signature recognition algorithms, and automatically communicate alert messages to pilots and air traffic controllers via data link.

Icing and Frost

1. Improve the frequency and accuracy of forecasting icing conditions.

2. To determine icing probability, icing areas, and accretion rates, develop a liquid water content device with an icing accretion indicator.

3. Develop methods of deicing aircraft on the ground, using other than water glycol mixtures or other petroleum products.

4. Better characterize icing information for the lower altitudes and reevaluate criteria in FAR, Part 25, Appendix C.

5. Include a note in the Airman's Information Manual about possible loss of control of some aircraft due to tail plane icing when the flaps are lowered.

6. Develop accurate frost forecasting capabilities.

Lightning and Atmospheric Electricity

1. NWS and FAA should analyze and test the usefulness of available lightning data to better define convective storm hazards.

2. Investigate the use of satellites and Doppler radar in thunderstorm detection and lightning forecasting.

Fog, Visibility, Ceilings, and Heavy Rain.

1. Assure greater accuracy and frequency in forecasting and reporting formation and dissipation of fog. Also improve the characterization of fog related information.

2. Examine the maintenance and reporting procedures for ground-based observation equipment. Develop improved low-cost visibility sensors and/or markers.

3. Improve the accuracy of the three- to four-hour prediction of terminal fog conditions through mesoscale observations and mesoscale forecast models or systems.

4. Develop and install a simplified, Automated Weather Observing System at other than primary Instrument Landing System equipped airports, capable of reporting altimeter, winds, temperature, ceiling, and runway visibility less than the VFR minimums to an in-flight aircraft, and also capable of digital telephone satellite link interrogation for input to a central data collection system.

5. Characterize heavy rain relative to concentration and its correlation to the wind speed phenomena known as microburst.

Summary of Recommendations

The individual recommendations presented in the previous subsections necessarily contain some duplication and overlap. The following recommendations were summarized by deleting repetition, and combining similar suggestions into a single recommendation.

Operational and Procedural Recommendations

These recommendations basically require some modifications to the current system, and do not require any new system development. Some of these recommendations are in the process of being incorporated or have been implemented.

1. Redefine CWSU functions and responsibilities.

2. Standardize pilot briefing formats and forms.

3. Standardize PIREP format and encourage solicitation and dissemination of PIREPs.

4. NWS should expand and continue use of NAFAX and DIFAX until replaced.

5. Improve completeness of NWS radar summary charts.

6. Retain AZRAN Code.

7. Revise AIM to reflect pilot briefing content.

8. Add dew point data to ATIS.

9. Present weather products in concise format and plain English.

10. Retain TWEB until Voice Response System is available.

11. Strengthen pilot aviation weather knowledge requirements.

12. Make weather minimums for uncontrolled airspace at night the same as for controlled airspace.

13. Require all FAR, PART 121 operators to have airborne radar.

14. Lower threshold criteria for taking special observations when RVR readings are less than 2400 ft. Revise procedures for placing these readings on Service A circuit.

15. Increase frequency of Terminal Forecasts to four times daily.

Recommendations Requiring Capital Investment

In order to meet these recommendations, major efforts would be required to enhance the existing weather service and develop new capabilities.

1. The FAA and NWS should develop a program to provide network weather reporting services to support instrument approaches at public use airports which have either published instrument approach procedures or a large number of based aircraft.

2. While automating the surface weather observation system and Flight Service Stations, maintain current number and quality of surface weather observations.

3. Improve upper wind measurements and forecasts for fixed-wing aircraft and winds aloft data at low altitudes for helicopters.

4. Provide accurate short-term forecasts.

5. Implement RRWDS at all FSSs with WBRR equipment.

6. Replace Service A with medium-high speed communication circuits.

7. Provide direct electronic communication link to sectors, TRACONs, towers, and possibly aircraft.

8. Provide real-time dissemination of hazardous weather.

9. Provide NWS ground weather radar information in cockpit and for preflight planning.

10. Provide rapid acquisition, processing, and dissemination of PIREPs.

11. Expand EFAS to include discrete high-altitude VHF and UHF.

12. Implement direct-access self-briefing terminals with automated flight plan filing capabilities in the current system. In the future, provide direct-access to the FAA computers.

13. Address AFOS, NMC, WMSC, and FAA weather systems interfaces to prevent loss of data.

14. Implement weather observation capabilities at many offshore platforms and remote heliports.

15. Provide accurate forecasts of hazardous weather to helicopters operating in offshore areas.

16. Develop accurate wind shear and hazardous weather detection capabilities with the ability to automatically disseminate information to the pilots.

17. Improve accuracy in predicting icing conditions for aircraft in-flight and awaiting departure and landing.

Major Areas of Enhancements from a User Perspective

These areas would specifically need either enhanced capabilities, or the development of a new system, in order to meet user needs.

1. Automated aviation weather observations: Develop a surface observation network to automatically provide improved quality (accuracy) and enhance availability of aviation weather observations.

2. Winds aloft data: expand the forecast data base to include data from other sources, viz Profilers, Aircraft Satellite Data Relay and Aircraft Meteorological Data Relay (AMDAR).

3. Wind shear and hazardous weather detection sensors: develop ground-based sensors and short-range, rapid update Doppler radar. The radar should be capable of interfacing with a computer which analyzes radar data and converts it into a message directly to the pilots.

4. Aircraft and runway icing prediction: develop means to measure runway friction and methods for deicing and encourage development of anti-icing systems for aircraft.

5. Improved short-term forecasting: through nowcasting and other capabilities, improve the accuracy and frequency of Terminal and Area Forecasts.

6. Effective use of PIREPs: provide means for rapid collection, handling, and dissemination of PIREPs through EFAS, Automated FSS, and possible direct communication with the CWSU.

7. Faster communication network: develop faster communication capabilities between controllers, facilities, and the users such as Mode S/data link and National Airspace Data Interchange Network.

8. FSS automation: provide rapid access to pilot briefings including graphical presentation of data. Encourage use of direct-access self-briefing terminals with a direct interface with the ATC planning computer.

9. Helicopter operations: improve weather data communication service, and provide additional surface observation capabilities for helicopter operations in the offshore areas.

APPENDIX B

USER REQUIREMENTS

The primary users of aviation weather information are pilots; however, controllers, FSS specialists, CWSU meteorologists and air carrier and private meteorologists also need weather data to perform their functions. The weather data and product requirements of these categories of users are summarized in this Appendix. Specific details related to the accuracy or resolution of individual weather measurements and products, and their display requirements, are also separately presented.

AIRSPACE USER REQUIREMENTS

Most pilots need basic weather information which includes observations and forecasts of temperature, dew point, pressure (altimeter settings), cloud cover, winds (surface and aloft), peak gusts, intensity of precipitation and visibility as well as the obstructions to visibility.

For these weather elements, the generalized requirement is basically to improve accuracy, frequency and resolution. The pilots must also know in advance of the hazardous weather conditions that should be avoided. As such, the main requirements are to have accurate hazardous weather detection and rapid dissemination capabilities. The specific weather needs of each group of airspace users are presented below.

- Pilot Requirements

Pilot Briefings for Flight Planning

The pilot briefings should contain the information the pilot actually needs for flight planning and for avoiding hazardous weather. Ideally, a briefing should contain the specific weather information relevant only to the desired route of flight. The following components of the routine and hazardous weather information are needed as a part of the idealized route specific preflight weather briefing.

a) NOTAMs for departure/destination/alternate airports

b) Enroute weather observations and navigation NOTAMs

c) Surface observations for departure/destination/alternate airports

d) Density altitude

e) Departure/destination/alternate airport Terminal Forecasts

f) Winds and temperatures aloft for various route segments at desired cruise altitudes

g) Cloud cover information

h) Surface visibility

i) Weather and tops

j) Area synopsis/outlook

k) AIRMETs, SIGMETs and Convective SIGMETs

l) Embedded thunderstorms - report location, intensity, movement, direction and speed

m) Squall lines along the desired route

n) Heavy precipitation (report areas)

o) Sustained surface winds - report winds greater than 30 knots

p) Icing and freezing levels

q) Turbulence amount, type and height, areas of occurrence

r) Hail - report size and areas of occurrence

s) Enroute PIREPs

t) Wind shear - report intensity

u) Tornadoes, waterspouts and funnel clouds - report location

v) Wake turbulence - report if considered hazardous

In-flight Weather Data Requirements

In-flight, the pilots should be able to obtain current observation weather data as needed. If there is a significant change in observed weather data, then the location, intensity, and movement of particular phenomena affecting flight operations should be updated, and the real-time updates communicated to the pilots.

Specific in-flight weather data requirements are:

a) Areas of severe weather, thunderstorms, turbulence and heavy precipitation

b) Winds and temperatures aloft at cruise altitudes

c) Sudden changes in winds aloft information

d) Hourly updates on destination/alternate airports weather and surface winds

e) Altimeter setting for destination/alternate airports

Accuracy Requirements for Surface Observations

The following paragraphs establish accuracy requirements for surface weather observation parameters.

a) Cloud Cover

Expressed as one of at least 3 gradations.

b) Ceiling

Accuracy required is ±50 feet for ceilings up to 500 feet, ±100 feet for ceilings from 500 to 1,500 feet and ±10% from 1,500 to 5,000 feet and to the nearest 500 feet for ceilings above 5,000 feet.

c) Surface Visibility

Accuracy shall be ±1/8 mile for visibilities up to 2 miles and ±1/4 mile for visibilities from 2 to 7 miles. Indications of the nature of obstructions to visibility shall be provided when visibility is less than 7 miles.

d) Runway Visibility

Accuracy shall be ±1% from 150 to 2,400 feet and ±5% from 2,400 to 6,000 feet

e) Precipitation

Type expressed as one of at least 3 intensity levels. The location of areas of precipitation shall be given with a positional accuracy of ±1.0 mile

f) Accumulation

Of snow, ice or water when it affects the usable landing surfaces of an airport

g) Temperature

Accuracy shall be ±1 degree for temperatures above -58°F, ±1.5 degrees for temperatures from -58°F to -65°F, and ±2 degrees for temperatures below -65°F

h) Dew Point

Accuracy shall be ±2 degrees F

i) Wind Speed and Direction

The accuracy shall be ±10 degrees in direction and ±2 knots for speeds up to 20 knots and ±10% for speeds from 20 to 80 knots. Observations shall indicate the speed of the sustained wind and shall also indicate peak speeds of gusts

j) Altimeter Setting

Accuracy shall be ±0.02 inch of mercury

k) Density Altitude

Accuracy shall be to the nearest 200 feet

Weather Avoidance Data Requirements

The pilots must be aware of the following conditions which could have an impact on the planning of the flight.

a) Strong surface winds (exceeding 30 knots)

b) Widespread low ceilings (less than 1,000 feet)

c) Widespread low visibilities (less than 3 miles)

d) Instrument Meteorological Conditions or Marginal VFR restrictions, heavy precipitation, lightning or hail

e) Severe weather, i.e., thunderstorms, icing, turbulence, wind shear, within vicinity of the airport and along the planned route.

Requirements for Surface Conditions Hazardous to Aircraft Operations

Heavy precipitation, i.e., snow (accumulations or drifts) and rain, should be reported as an occurrence when it affects the usable runway surfaces of the airport with the following requirements.

a) Snow depth on airport usable surfaces should be given to the nearest one-half inch up to 3 inches, to the nearest inch from 3 inches to one foot, and with an indication of "1-foot plus" whenever snow accumulation exceeds one foot

b) Slush depth on airport usable surfaces should be given to the nearest one eighth inch up to one half inch, to the nearest one quarter inch up to one inch, to the nearest half inch from 1 to 2 inches, and with an indication of "2 inches plus" when over 2 inches

c) Standing water on the runway should be given to the nearest 1/8 inch up to 1/2 inch, to the nearest 1/4 inch from 1/2 inch to 1 inch, to the nearest 1/2 inch from 1 to 2 inches and with an indication of "2 inches plus" when over 2 inches

d) Ice on runways should be reported as compacted, wet, glazed, rough or under snow

e) Runway braking action, if available, should be given as nil, poor, fair, and good.

Regulatory Requirements

a) Before a flight, each pilot-in-command must familiarize himself with all available weather reports and forecasts.

b) Alternate airport(s) must be indicated on an IFR flight plan if there is no standard instrument approach procedure for the first airport of intended landing. If an instrument approach procedure is available and the weather reports/forecasts indicate a ceiling of less than 2,000 feet and visibility less than 3 miles, an alternate airport must be indicated. Weather forecasts must be at or above the published minimums for an instrument approach procedure at the alternate airport, or if no minimums are specified, ceiling and visibility will be at or above 600 feet and 2 miles for a precision approach, and 800 feet and 2 miles for a non-precision approach.

c) Air taxi and commuter aircraft must have approved thunderstorm detection equipment; large aircraft must have airborne weather radar equipment; and the pilot of either type aircraft must have current weather reports before beginning a flight under IFR or night VFR conditions.

d) Air taxi and commuter pilots must use weather information provided by NWS, or a source approved by NWS, or a source approved by the Administrator, for IFR operations, but may use their own weather observations for VFR operations. The pilots conducting IFR operations at an airport must use weather observations taken at that airport unless the Administrator approves observations taken at a location different from that airport.

e) The pilots must know forecast icing conditions under VFR or IFR.

f) No pilot of an aircraft carrying passengers at night may take off from, or land at an airport, unless that pilot has determined the wind direction from an illuminated wind direction indicator, local ground communications or, in the case of take off, from the pilot's personal observations.

g) Whenever a pilot encounters a potentially hazardous meteorological condition in flight, the knowledge of which the pilot considers essential to the safety of other flights, the pilot shall notify an appropriate ground radio station as soon as practicable.

h) No person may take off an aircraft under IFR, or over-the-top operation, or designate an alternate airport, unless the latest weather reports or forecasts, or any combination thereof, indicate that weather conditions at the estimated time of arrival at the next airport of intended landing will be at or above authorized IFR landing minimums.

- Airline Dispatcher Requirements

Although airline dispatchers provide the essential weather information to the flight crew, the dispatchers themselves receive most of the weather data and charts from the NWS/FAA.

Their requirements are:

a) Surface weather analysis and prognosis charts

b) Radar summary charts

c) Satellite pictures

d) Severe weather outlook charts

e) High level severe weather information (clear air turbulence)

f) Upper winds and temperature information

g) Weather depiction charts

h) Freezing level charts

i) Constant pressure chart

j) Constant pressure prognosis chart

k) Surface maximum/minimum forecast chart

l) 400 - 70 millibar significant weather chart.

m) Terminal and Area Forecasts

n) Surface observations

o) Weather advisories

Regulatory Requirements for Airline Dispatchers

a) Air carriers and commercial aircraft operators must use weather information provided by NWS, or a source approved by NWS in the 48 States, and Administrator approved services outside the U.S.

b) No person may dispatch an aircraft (or initiate the flight of an aircraft in the case of an air carrier or commercial operator that does not use a dispatch system) under IFR or night VFR conditions, when current weather reports indicate that thunderstorms, or other potentially hazardous weather conditions that can be detected with airborne weather radar, may reasonably be expected along the route to be flown, unless the airborne weather radar equipment is in satisfactory operating condition.

c) The dispatch release and flight release must contain, or have attached to it, weather reports, available weather forecasts, or a combination thereof, for the destination airport, intermediate stops, and alternate airports, that are the latest available at the time the release is signed by the pilot-in-command and the dispatcher. It may include any additional available weather reports or forecasts that the pilot-in-command or the aircraft dispatcher considers necessary or desirable.

d) No person may dispatch or release an aircraft for a flight that involves extended over water operation, unless appropriate weather reports, or forecasts, or any combination thereof, indicate that the weather conditions will be at or above the authorized minimums at the estimated time of arrival at any airport to which the aircraft is dispatched.

e) No person may dispatch or release an aircraft, continue to operate an aircraft en route, or land an aircraft, when in the opinion of the pilot-in-command or aircraft dispatcher (domestic and flag air carriers only), icing conditions are expected that might adversely affect the safety of the flight.

- Helicopter Pilot Requirements

The helicopter operations can be classified into two categories. The first category includes in-land operations where the helicopters fly over short route segments at low altitudes. The second category of operations are in remote or offshore areas to the oil rigs. The differences in requirements for offshore areas result from the unavailability of weather-related data due to lack of services. Presented in this subsection are specific requirements for these two categories of helicopter operations.

Weather Needs for Helicopter Operations Over Land

The overall weather data requirements are almost the same as for fixed-wing pilots. However, because the commuter helicopters operate in the lower altitude structure over short route segments, pilots need short term forecasts (0 - 1 hour) at these low altitudes. Helicopters are more susceptible to high winds and formation of ice; therefore, in addition to fixed-wing pilots weather data requirements, helicopters also need to receive the following information:

a) Low-altitude, short-term forecasts of winds, pressure, cloud cover and icing conditions

b) A weather observation capability (gap filler) such as Automated Weather Observing System to provide weather service at in-land heliports where there is no service available at present

c) Density altitude

Weather Needs for Offshore Operations

The following weather services are needed:

a) Provide short term (0-1 hour) en route forecast for low altitudes (surface to 5,000 feet)

b) Add communications to cover offshore remote areas

c) Add "gap filler" weather observation stations at offshore sites and provide density altitude

Regulatory Weather Requirements for Helicopter Operators

a) When the visibility is less than one mile, a helicopter may be operated outside controlled airspace at 1,200 feet, or less, above the surface, if operated at a speed that allows the pilot adequate opportunity to see any air traffic, or other obstruction, in time to avoid a collision.

b) The helicopter pilot must have knowledge of the weather characteristics of the route to be flown.

c) Each helicopter operator must notify its operations personnel of hazardous weather conditions.

d) During a flight, the operational control center must furnish the helicopter pilots any information of meteorological conditions that may affect the safety of the flight.

e) No person may release a helicopter for VFR operations, unless the ceiling and visibility forecasts at the heliports to be used on the route are known.

f) The helicopter pilot must know forecasts of en route icing conditions.

- Weather Data Needs For Oceanic Flights

The aircraft operating on oceanic routes use certain airports in the U.S. designated by the International Civil Aviation Organization (ICAO) as international airports. Winds and temperatures aloft forecast for 300 mb, 250 mb, 200 mb, and 150 mb and tropopause height information are needed for the Organized Track System (OTS) across the Atlantic. Besides weather data needs listed for domestic flights earlier, the following weather data requirements have been specified in ICAO procedures.

Upper Winds Forecasts

Route forecasts should contain upper winds, upper air temperatures, significant en route weather phenomena and associated clouds. This information should cover the flight operations for which they are intended with respect to time, altitude and geographical extent.

Significant Meteorological Information

SIGMETs should give specific information on hazardous en route weather phenomena that include the occurrence, and/or expected occurrence, of one or more of the following:

a) At subsonic aircraft cruising levels:

   i. Active thunderstorms

   ii. Tropical revolving storm

   iii. Severe squall line

   iv. Heavy hail

   v. Severe turbulence

   vi. Severe icing

   vii. Marked mountain waves

b) At transonic and supersonic aircraft cruising levels:

   i. Moderate or severe turbulence

   ii. Cumulonimbus clouds

   iii. Hail

The requirement to issue SIGMET information regarding active thunderstorms, refers to the occurrence, or expected occurrence, of an area of widespread cumulonimbus clouds (Cb) along a line with little or no space between individual clouds, or to Cb embedded in cloud layers, or concealed by haze.

Special Airport Observation Reports

Reports of special observations indicating changes in accordance with the following criteria should be prepared as selected special reports:

a) When the mean surface wind direction has changed by 30 degrees or more from that given in the latest report, the mean speed before and/or after the change being 20 knots or more;

b) When the mean surface wind speed has changed by 10 knots or more from that given in the latest report, the mean speed before and/or after the change being 30 knots or more;

c) When the variations from the mean surface wind speed (gusts) has increased by 10 knots or more from that given in the latest report, the mean speed before and/or after the change being 15 knots or more; or

d) When a thunderstorm, hail, snow and rain mixed, freezing precipitation, drifting snow, squall or funnel cloud (tornado or waterspout) begins or ends or changes in intensity.

International Regulatory Requirements

Special observations shall be made by all aircraft operating on international air routes whenever:

a) Weather phenomena specified for SIGMET messages are encountered that, in the opinion of the pilot-in-command, may affect the safety or markedly affect the efficiency of other aircraft operations;

b) Severe turbulence or severe icing is encountered; or

c) Moderate turbulence, hail or cumulonimbus clouds are encountered during transonic or supersonic flight.

AIR TRAFFIC CONTROL WEATHER INFORMATION REQUIREMENTS

- Air Traffic Controllers Requirements

The ATC personnel interfacing directly with the pilots are primarily the air traffic controllers in towers, TRACONs and control centers, and the FSS/EFAS specialists. Other than these specialists who need routine and hazardous weather information with sufficient warning and accuracy to properly provide the pilots with preflight and in-flight weather briefings, the controllers may not routinely participate in handling of weather information. However, in order to assure a safe and expeditious flow of traffic, the controllers do have specific weather requirements.

Controller Weather Data and Display Requirements

For take-offs and landings, the tower controllers utilize some of the information contained in the surface observation reports. The resolutions and accuracies presented earlier also apply to the weather data observation requirements, as expressed by tower controllers. In addition, tower controllers need radar echo intensity showing levels of precipitation, and wind shear information (location, direction of movement and speed), which should be displayed alphanumerically, and preferably in graphical format, for the entire terminal area up to 2,000 feet AGL for each arrival and departure corridor.

The following information is needed by the TRACON controllers.

a) Airport weather observations

b) Real-time upper wind information from surface to 10,000 feet (displayed alphanumerically) accurate to the nearest 10 degrees and 5 knots

c) Synoptic information relating Terminal and Area Forecasts

d) Graphic depictions of convective activity, thunderstorm development, hazardous weather areas, level of turbulence (light to moderate), and information on tornadoes

e) PIREPs relating icing, clear air turbulence, hail and heavy precipitation.

The elements of weather information required by all en route sector controllers, in addition to the Terminal and Area Forecasts are:

a) Observations at airports within the area of jurisdiction

b) Selective graphic display of cloud layers to include cloud tops and bases from surface to 60,000 ft. and for a radius of 200 nmi from any selected location

c) Display of upper wind data from 5,000 to 60,000 ft. in 1,000 foot increments up to FL 290 and in 2,000 ft. increments above FL 290.

d) Capability to graphically plot selected weather (PIREPs, SIGMETs, measured tops and upper winds) within some distance (50 nmi) either side of a specified route

e) Display of radar derived hazardous weather based on severity of hazard (e.g., reflectivity levels 1-6)

f) Hazardous weather area forecasts (nowcasts).

- Flight Service Station Specialist Weather Data Requirements

The specific weather related requirements are generally listed in the joint Departments of Commerce and Transportation document, Advisory Circular 00-45B entitled: "Aviation Weather Services." They are not measurable requirements as those listed for the pilots and controllers, but rather consist of reports, forecasts, and analyses produced by the NWS. The data required by pilots are extracted from these products by the FSS specialist and then communicated to the pilots.

These products are:

a) Surface aviation weather reports

b) Radar weather reports

c) Terminal Forecasts

d) Area Forecasts

e) TWEB route forecasts

f) In-flight advisories (AIRMETs, SIGMETs and Convective SIGMETs)

g) Winds and temperatures aloft forecasts

h) Special flight forecasts

i) Severe weather watch bulletins

j) Surface analyses

k) Weather depiction charts

l) Radar summary charts

m) Significant weather prognostics

n) Freezing level charts

o) Constant pressure charts

p) Constant pressure prognostics

q) Cloud information based on satellite data.

In addition to these products as requirements, the FSS specialist also requires pilot reports to confirm the forecast information, or make him aware of hazards which could affect other pilots in the area. In addition, the FSS specialist requires weather radar and weather satellite information.

- **Center Weather Service Unit Meteorologist Requirements**

The CWSU meteorologists need all the weather information required by the meteorologists in the Weather Service Forecast Offices, including real-time severe weather information. In order to track thunderstorms, clear air turbulence, pressure, ceiling and visibility trends in areas of interest, etc., the CWSU meteorologists also need the FSS specialist weather products mentioned earlier. Additional data and display requirements are:

a) Capability to generate plots of upper air sounding data for significant pressure levels, including wind data and height of pressure surface, as provided in the sounding messages

b) Isopleth contouring of data

c) Capability for simultaneous display and animation of satellite and radar imagery

d) Ability to receive, contour and display digital weather radar data from RRWDS

e) Real-time alerts for externally generated (FSS/EFAS) urgent PIREPs.

f) GOES pictures of cloud systems at 30-minutes interval.

- **Requirements for Central Flow Control Facility**

The meteorologists in Central Flow Control Facility have essentially the same weather information requirements as those for CWSU meteorologists given in the previous subsection. The basic difference is that these meteorologists need weather information for the entire conterminous U.S., that should include:

a) Surface analysis of existing weather at medium and high-density airports

b) Upper air situation at 1,000 ft. increments up to FL 290 and 2,000 ft. increments above FL 290

c) Orientation of jet stream and associated arcas of clear air turbulence

d) Short-term forecasts

- Weather Products Needed by Area Control Computer Complex

In Area Control Facilities, the Area Control Computer Complex would need the following weather data and products for processing.

a) ARSR data and NWS radar weather contours showing real-time precipitation and turbulence

b) Current and predicted areas of hazardous weather and hurricane advisories

c) Winds and temperature aloft data

d) Surface observations

e) Altimeter readings

f) Terminal Forecasts

g) Area Forecasts

h) PIREPs and PIREPs summary

i) All Center Weather Advisories

j) AIRMETs, SIGMETs and Convective SIGMETs

k) NOTAMs

l) Convective outlook

m) Meteorological Impact Statement

n) Severe weather forecasts

o) Hurricane advisories

- Weather Requirements for Automated En Route Air Traffic Control

Automated En Route Air Traffic Control (AERA) will require accurate winds and temperature data to predict aircraft position as a function of time for metering, and severe weather information for conflict prediction and avoidance.

The following winds and weather information will be required by AERA:

Winds and Temperature Aloft

AERA will require the winds and temperature data with the following resolution.

a) 50nmi x 50nmi grids

b) Every 1,000 ft. in altitude from surface to 29,000 ft. and every 2,000 ft. from 29,000 ft. to 60,000 ft.

c) Prevailing winds and temperatures updated every 30 minutes

The data update rate should be variable to achieve reasonable possible accuracy. The data should be accurate enough to predict aircraft ground speed within ± 10 knots and headings within ± 10 degrees.

Severe Weather Observations/Forecasts

AERA will require the severe weather area in polygon format with centroid and velocity vector. The contours may be annotated with the following information:

a) Bases and tops of the weather

b) Severity code

c) Velocity vector confidence level

Weather Radar Observations

Weather radar contours of precipitation and turbulence would be required for controllers display in the AERA environment. The requirements in terms of discrete levels of precipitation and turbulence would be defined in conjunction with AERA weather display formats.

Synoptic Weather Information

AERA would require textual weather information for automatically relaying to the pilots upon request. These weather messages may include: surface observations, Terminal Forecasts, Convective SIGMETS, severe weather warnings, etc.

NATIONAL WEATHER SERVICE REQUIREMENTS

The success of the aviation weather support program is dependent upon a comprehensive database, and rapid processing and dissemination capabilities, including effective quality control and evaluation effort of aviation weather products and services. The following are the NWS specific requirements.

a) A program is needed for formally training aviation weather forecasters.

b) Convective SIGMETs valid for up to 2 hours concern only thunderstorms for the conterminous U.S. and are issued based on radar and satellite information. Therefore, existing radar and satellite data sources must be maintained and systems for transmitting, manipulating, and analyzing these data must be enhanced.

c) Nonconvective SIGMETs valid for up to 4 hours concern icing, turbulence, dust and sandstorms, as well as volcanic ash and are issued based on pilot reports, upper air observations, and guidance products from computer models of the atmosphere. Therefore, improved reporting and handling of pilot reports, an updated, denser upper air observation network, and improved icing and turbulence definitions and objective forecast techniques are required to enhance the detail and timeliness of these advisories.

d) AIRMETs valid for up to 6 hours concern low clouds and visibility, icing, turbulence and strong wind and are based upon the same information used for SIGMETs plus the aviation surface observation network. Consequently, an adequate surface observation network, particularly in or near mountainous areas, is vital. Therefore, the addition of automated surface observations comparable to or better than current manual observations required to maintain the quality of these advisories.

e) The major data requirement for area and route forecasts is surface and upper air observations, that is en route observations, e.g., PIREPs and satellite cloud picture. The current network is generally adequate during daytime hours. However, during nighttime and early morning hours when flight briefings and decisions are being made, many observations are not available.

f) In order to sustain the current level of forecasting details, the automated observation systems must be able to measure cloud heights and amounts up to 10,000 ft. plus and should have the capability to detect and discern the type of weather, i.e., liquid, freezing, and frozen precipitation, as well as thunderstorms.

g) For international SIGMETs, it is essential that the meteorological watch offices have current meteorological information covering the assigned airspace including aircraft meteorological reports (AIREPs), upper air soundings, meteorological radar and satellite data.

AVIATION WEATHER REQUIREMENTS FOR AGRICULTURE

In farming, aircraft operations are used for crop dusting, i.e., spraying herbicide or pesticide. The spraying operations are affected by winds, temperature and turbulence in addition to the fact that the weather must be safe for flying. Basic requirements for safe operations are the same as those for the general aviation pilots. The following are the specific requirements for these agricultural operations.

a) Weather forecast for the area to be sprayed is needed in the morning between 4 to 5 a.m. for go/no go decision

b) Area Forecasts are required in-flight, if spraying process is expected to last more than 1 hour

c) Accurate information is required on winds, temperature, and dew point.

AVIATION WEATHER REQUIREMENTS FOR FORESTRY

Flight operations are used for forest fire management when air temperatures are above freezing. The basic pilot requirements for these operations are the same as for general aviation aircraft. However, the following resolution for weather data is required for these forest fire fighting operations.

a) Wind Speed - 5 kts speed ≤ 20 kts
(Surface to 500 mb) - 7 kts $20 < \text{speed} \leq 40$ kts
- 10 kts speed > 40 kts
b) Wind direction - 25 degrees

c) Temperature - 6 degrees

d) Relative humidity - 10 %

e) Precipitation probability - 5 %

DEPARTMENT OF DEFENSE WEATHER REQUIREMENTS

Military Operations

In ARTCC jurisdictions that have military operations, a workstation Aircraft Movement Information Service (AMIS) desk is provided for a military liaison officer and a specialist. The weather data for these people are available through coordination with the ARTCC staff.

- ### U.S. Army and Air Force Requirements

In order to meet the aviation weather requirements of U.S. Army and Air Force in the future, DoD is developing an Automated Weather Distribution System (AWDS) to provide automated meteorological support to fixed and tactical operations. Even though AWDS should meet most of the requirements, there are certain areas where meteorological support may be needed from FAA/NWS. Specific DoD requirements are not available at the present time, however, DoD would need to share weather information, data or results in the following areas:

a) NEXRAD data

b) Aircraft (specially rotary-wing) icing

c) Turbulence

d) Low-level wind shear

- ### U.S. Naval Requirements

The weather information required from FAA/NWS for naval operations (fixed wing aircraft and helicopter operations for U.S. Navy, Coast Guard and Marines) is covered in sections on oceanic and helicopter pilot requirements.

Navy and Marine Corps basic data requirements for aviation weather support within the U.S. are provided through several sources. Teletype (alphanumeric) data is primarily provided via the CONUS Meteorological Data System (COMEDS) managed by the U.S. Air Force as part of the Automated Weather Network (AWN). NWS/NOAA NAFAX and DIFAX services provide primary facsimile support. Additionally, most Navy and Marine Corps aviation weather support activities in the U.S. have a Geostationary Orbiting Environmental Satellite facsimile reception capability.

The following paragraphs describe the specific requirements for naval operations.

Because naval aviation utilizes shore-based facilities, both in the U.S. and overseas, and conducts flight operations from mobile platforms such as aircraft carriers and other aviation-capable ships, there are unique requirements associated with this type of operations over water.

Information on sea surface temperatures, minimum altimeter settings, remote area visibilities and possible ditch headings are required for low level over water operations. Sea-based operations require additional information such as:

a) Wave height, period, and direction data

b) Sea-ice accretion data

c) Winds-over-the-deck

The following hazardous weather detection capabilities are required:

d) Detection and display locations of lightning strokes

e) Digital radar display system to support the tracking/prediction of thunderstorm movement and intensity

f) Improvement of accuracy and resolution of synoptic and mesoscale wind forecast essential for aircraft carrier (and other sea-based) operational flight planning

g) Development of an advanced automatic weather station to provide constant measuring of ambient atmospheric parameters with a visual display console

h) Mobile satellite acquisition and display system to receive and display high resolution Defense Meteorological Satellite Program (DMSP) data.

APPENDIX C

NTSB EVALUATION OF WEATHER RELATED AIRCRAFT ACCIDENTS

The interaction between the NTSB and the FAA following 10 weather-related aircraft accidents over the last decade is summarized in this Appendix. The information provided includes general facts about each accident and a table to be read as follows:

1. NTSB Recommendations. In this column, the recommendations issued by NTSB after each accident are summarized. An indication of the subject addressed in each recommendation is given between parentheses right after the recommendation's number. Recommendations pertaining to weather only are reported.

2. FAA Reply. The corresponding FAA reply is presented across each recommendation. If several letters were sent to answer the same recommendation, the most recent reply is presented.

3. Status. This column represents the status of acceptability of FAA's reply to NTSB. Recommendations usually remain in an "open" status until proper action has been taken by FAA. Once a recommendation is put in a "closed" status, no further action is expected from the FAA. The acronyms used in the table are to be interpreted as follows:

CAA:	Closed - Acceptable Action
OAA:	Open - Acceptable Action
OAAA:	Open - Acceptable Alternate Action
CAAA:	Closed - Acceptable Alternate Action
OUA:	Open - Unacceptable Action
CUA:	Closed - Unacceptable Action

4. FAA Program/Status of Action: Programs underway at the FAA or developed jointly with other agencies to answer some of NTSB recommendations are listed in this column. Also indicated are various actions taken by the FAA to satisfy the intent of the recommendation, including the publication of official notices.

The information presented in this appendix is based upon the current status of interaction between the NTSB and the FAA. Since some of the recommendations are still in an "open" status, further interaction is expected to continue in the future.

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Delta Airlines Accident at Dallas/Fort Worth, Texas.

Date: 8/2/85

Flight Number: 191

Aircraft Type: L1011

Casualties: 132 (131 in aircraft, 1 on ground)

Primary Report (NTSB): Flight 191 was executing an ILS approach to runway 17L of Dallas/Fort Worth International Airport either very close to or directly beneath a rapidly intensifying weather cell. The airplane struck the ground about 2,000 feet north of the approach end of runway 17L, hit a car on the access highway killing the driver, struck a water tank, and came to rest a few hundred feet short of the runway. Except for a section of the airplane containing the aft fuselage and empennage, the remainder of the airplane disintegrated during the impact sequence. Twenty-nine passengers and three cabin attendants seated in the aft section of the cabin survived.

Note: No recommendation has been issued by NTSB as yet.

Pan American World Airways Accident at Kenner, Louisiana.

Date: 7/9/82

Flight Number: 759

Aircraft Type: Boeing 727

Casualties: 153 (145 in aircraft, 8 on ground)

Causes: (as determined by NTSB): Microburst, downdraft caused the plane to loose altitude. As the aircraft started regaining altitude, it struck a tree and crashed.

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TABLE C-1
NTSB/FAA INTERACTION AFTER PAN AM 759 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued March 25, 1983 • A-83-13 (Wind Shear Detection) Review all Low Level Wind Shear Alert System (LLWAS) to identify possible deficiencies in coverage (Class II Priority Action)	July 21, 1983: FAA has placed LLWAS on the National Airspace Performance Reporting System list which means all deficiencies must be reported and repaired on a priority basis.	CAAA[a]	West sensor at New Orleans International Airport is being replaced with ruggedized sensor with no moving parts to reduce risks of vandalism. May 29, 1984: FAA's action should eliminate the possibility of LLWAS coverage gaps. NTSB accepts this action as an acceptable alternative to performing a one-time review system installations.
• A-83-14 (Information/ LLWAS) Inform the aviation community of 1) Location and designation of LLWAS 2) Capabilities and limitations of LLWAS effort to standardize published LLWAS information (avail. Nov. 1983)	Proposed amendment to FAA Handbook 7210.3F para. 1222 to require issuance of a Letter to Airmen by all LLWAS facilities containing this information. A sample letter will also be prepared for distribution to all regions in an April 2, 1985: FAA published a letter to airmen (November 24, 1983) explaining the Low Level Wind Shear Alert System (LLWAS). FAA believes that publishing information via a letter to airmen is a superior means of getting information to those who use the system. The Airport/Facility Directory indicates whether or not a facility is equipped with LLWAS. Jeppesen Company has requested the FAA to provide an LLWAS location data base in order to indicate LLWAS sensor locations on the airport diagram of the instrument approach procedure charts.	OAA[b]	May 29, 1984: NTSB finds the changes to FAA handbook responsive to the intent of recommendation but suggests that the FAA also publishes information on the capabilities and limitations of the LLWAS and the availability of remote sensor information in the Airman's Information Manual (AIM). Location and designation of remote sensors should also be included in Airport/Facility Directory. Pending publication of amendment to FAA handbook and the review of sample letter to regions, NTSB maintains the status of this recommendation open.

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[a] CAAA: Closed Acceptable Alternate Action
[b] OAA: Open Acceptable Action

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TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-15 (Information/ LLWAS) Record output data from all installed LLWAS sensor for use in reconstructing wind shear event and use as a basis for system (Class II, Priority Action).	July 21, 1983: FAA developing a plan to install data recorders on LLWAS. Data recorded will tabulate number of times wind shear alerts occurred, wind shear velocity, and the duration of the event (avail. Jan. 1984).	OAA[a]	May 29, 1984: NTSB is pleased with action and urges the FAA to ensure that the plan requires the data to be recorded in sufficient detail to allow the reconstruction of wind shear events and development of system improvements.
• A-83-16 (Dissemination of Information/Wind Shear) Emphasize to pilots on a continuing basis the importance of making prompt reports of wind shear with prescribed reporting guidelines and make sure ATC personnel transmit such reports to pilots promptly (Class II, Priority Action).	Currently, pilot weather reports are addressed in the Airman's Information manual (AIM), paragraph 520, wind shear pilot reports in AIM, para. 523 and operational aspects of the LLWAS in AIM para. 227. Proposed change to AIM para. 520 to include wind shear as a reportable, significant flight condition and urge pilots to promptly send reports of wind shear to ATC facility. para. 227 and 523 would also be expanded to include same recommendation. (effective Nov. 24, 1983). April 2, 1985: FAA's Office of Flight Operations continues to emphasize the importance of communication of wind shear encounters by flight crews. An informational film, the current AC Advisory Circular (AC) 00-50A, Low Level Wind Shear, and the corrected AIM reflect this effort. FAA plans to continue to emphasize the need for communication in current airman education programs, as well as in forthcoming programs.	OAA	- Air Traffic Service (ATS) Bulletin No. 83-2 was published (June 1983). Two articles in this dealing with wind shear "Low Level Wind Shear. Its Characteristics and the Controllers Responsibility" and "Characteristics of Micrbursts." - Advisory Circular (AC) 00-50A "Low Level Wind Shear" addresses the subject of pilot reports (PIREPS) May 29, 1984: NTSB find proposed changes to AIM responsive to the intent of this recommendations. Status maintained open pending implementation of changes.

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[a] OAA: Open-Acceptable Action

TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued March 25, 1983 • A-83-17 (Dissemination of Information/Wind Shear) Require that ATIS advisories be amended promptly to provide current wind shear or other hazardous weather information in the terminal area as provided by CWSU meteorologists. Issue blind broadcast to all aircraft in terminal area when new ATIS has been issued (Class II, Priority Action)	July 21, 1983: A change to Handbook 7210.3F para. 1230, ATIS, effective Aug. 4, 1983 requires the appropriate controller to "broadcast once on all frequencies, except emergency frequencies, to advise aircraft of a change in the ATIS code/message." April 2, 1985: FAA Handbook 7210.3G, Para. 1230 requires a new Automatic Terminal Information Service (ATIS) recording to be made when there is a change in pertinent data such as NOTAMs/SIGMETs/PIREPs, etc. Center Weather Advisories are included in Paras. 1220 and 1230 to be required as part of the ATIS.	OUA[a]	Currently, the Handbook 7210.3F para. 1230 requires "NOTAM's and notification of PIREP's, SIGMET's/Convective SIGMET's pertinent to operations in the terminal area" to be included in the ATIS. May 29, 1984: NTSB finds changes to FAA Handbook 7210.3F para. 1230 only partly responsive to its recommendation. Hazardous weather advisories pertinent to the terminal area provided by CWSU meteorologists are not currently required to be included in the ATIS broadcast. They should be included in ATIS broadcast.

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[a] OUA: Open-Unacceptable Action

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TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-18 (Information) Evaluate methods and procedures for the use of current weather information from sources such as radar, Low Level Wind Shear Alert Systems, and pilot reports as criteria for delaying approach and departure operations which would expose the flight to low altitude penetration of severe convective weather (Class II, Priority Action).	July 21, 1983: Currently there are several documents available which provide a pilot with information regarding weather analysis and avoidance criteria. These documents are ACOB's, Airman's Information Manual and air carrier training programs. April 2, 1985: This recommendation was discussed with the National Academy of Sciences' panel on Low Level Wind Shear and its hazard to aviation. It was suggested that information from existing weather radars should be made available to air traffic controllers in a timely and easily understood manner. FAA is now investigating the feasibility of providing NWS radar information to control tower cabs. The only equipment having the potential to provide sufficient information is the Doppler. The FAA is currently testing ground-based Doppler radar at Denver, CO and at Memphis, TN. These programs will help determine, if a go/no-go decision can be made on using this equipment more widely.	OUA[a]	May 29, 1984: NTSB agrees with FAA's response but believes that there is a need to evaluate methods and procedures for the use of available weather information as criteria for making go/no go decisions in severe weather conditions.

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[a] OUA: Open-Unacceptable Action

TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued March 25, 1983 • A-83-19 (Operational Procedures/Wind Shear) Study the feasibility of establishing aircraft operational limitations based on the data available from the Low Level Wind Shear System (Class II, Priority Action)	LLWAS is the best system available today and is used by pilots to help make operational decisions regarding severe convective weather. LLWAS derived information, however, is not necessarily adequate to qualify the intensity of the weather hazard and must be complemented by other information.	OUA[a]	NEXRAD will provide improved information on horizontal shear strength but not on vertical shears. May 29, 1984: NTSB believes that the use of LLWAS for operational decisions could be optimized if a pilot was able to compare the longitudinal wind gradient which is measured by LLWAS to the hazard it presents to his particular airplane. These capabilities should be kept in mind when changes to LLWAS software and other system enhancements are considered.
• A-83-20 ((LLWAS Display) Make the necessary changes display Low Level Wind Shear Alert System wind output data as longitudinal and lateral components to the runway centerline (Class II, Priority Action)	Evaluation program will be conducted using an enhanced LLWAS at New Orleans Airport. Various displays of wind sensor information will be evaluated. April 2, 1985: The FAA Technical Center is examining the capability of LLWAS to output data as longitudinal and lateral components to the runway center line. After the data is examined, a decision will be made as to implementing this type of report with the LLWAS (by July, 1985).	OAA[b]	Current study on wind shear conducted at the National Academy of Science also examining possible improvements to the LLWAS. May 29, 1984: Planned evaluation of various displays of wind sensor information during the New Orleans International Airport Test Program is responsive to this recommendations. Pending its review of results, NTSB maintains this recommendation in an open status

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[a] OUA: Open-Unacceptable Action
[b] OAA: Open-Acceptable Action

TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-21 (Research) Use data obtained from JAWS project and other relevant data to 1-quantify the low-level wind shear hazard/-impact on airplane performance 2-evaluate the effectiveness of LLWAS and needed improvements to the aerodynamic penalties of precipitation on airplane performance (Class II, Priority Action).	July 21, 1983: The effect of low level wind shear on aircraft performance is a subject of the National Academy of Science study. Recommendations will be issued for the criteria, basis, content, communication, and display of and warning to pilots and ATC personnel, and for improving our ability to conduct safe aircraft operations (final report Sep. 1983) March 25, 1983: JAWS data being used to assist in siting additional LLWAS sensors at New Orleans International Airport	OAA[a]	- Purpose of National Academy of Science study is to review the state of knowledge of low level wind shear and variability which is hazardous to aviation in the terminal area. - NASA currently performing a study on effects of precipitation on airplane performance. May 29, 1984: Studies conducted by the National Academy of Science, NASA and the LLWAS Test Program at New Orleans are responsive to the intent of this recommendation.

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[a] OAA: Open-Acceptable Action

TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-22 (Research) Use JAWS Project data to 1) Develop training aids for pilots and controllers to emphasize the hazards associated with convective weather activity 2) develop microburst wind models for incorporation into pilot flight simulator training programs, 3) promote the development of airborne wind shear detection devices (Class II, Priority Action).	- FAA plans to develop an informational film for use by pilots and controllers detailing hazards associated with convective weather, as part of JAWS Project. (To be completed by April 1984) - Data from JAWS program will be used to develop updated realistic microburst/downburst models - FAA, in promoting the development of airborne wind shear detection devices, has drafted and circulated within industry an AC on that subject	OAA[a]	Industry/Government meeting scheduled in September 1983 to finalize wind shear model definition and use for training. NASA is currently developing design guidelines for changes needed to improve the performance of airborne Doppler radars. May 29, 1984: The international film, the reduction of JAWS data for use in simulator training of pilots, and the continued research in airborne detection devices are responsive to this recommendation. Pending review of wind models and progress of research in area of wind shear detection devices, recommendation is maintained in an open status.
• A-83-23 (New Equipment/Wind Shear) Expedite the development, testing and installation of advanced Doppler weather radar to detect hazardous wind shear in airport areas. Expedite installation of add-on Doppler for detection of wind shear in high risk terminal areas (Class II, Priority Action)	July 21, 1983: FAA is pursuing the development of airport terminal Doppler weather radar in the most expeditious manner possible. Best method is to provide intensity contours of precipitation and turbulence derived from the Doppler weather radar directly on airport surveillance radar display.	OAA	Current schedule calls for first system installation in late 1987 and all systems installed by 1992. Add on Doppler to existing weather radar still require development of the software to detect and extract wind shear characteristics and present the information on the controllers display. May 29, 1984: NTSB urges the FAA to continue to explore the feasibility of using currently available Doppler Weather Radar Syst. such as the one in Montgomery as interim systems prior to the development of NEXRAD.

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[a] OAA: Open-Acceptable Action

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TABLE C-1
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-25 (Training) Recommend to air carriers that they modify pilot training on simulators capable of reproducing wind shear models so as to include microburst penetration demonstrations during takeoff, approach, and other critical phases of flight (Class II, Priority Action).	Definitive data on microbursts are being prepared by the National Center for Atmospheric Research. Results will be transmitted as soon as possible and implemented into air carriers simulator programs April 2, 1985: FAA is working very closely with the National Center for Atmospheric Research, the Air Transport Association Wind Shear Task Force, aircraft manufacturers and several air carriers for the purpose of developing the most beneficial wind shear training wind shear simulator models (using data from JAWS project). However, simulator training is not a requirement for air carriers and, therefore, wind shear training in simulators cannot be mandated at the present time.	OAA[a]	FAA will continue to encourage the air carriers to implement improved wind shear models for their simulators which may include microburst demonstrations. May 29, 1984: Effort by FAA and industry is acknowledged. Pending full development and use of the wind shear microburst models in training simulators, NTSB will maintain this recommendation in an open status.

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[a] OAA: Open-Acceptable Action

TABLE C-1
(Concluded)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-83-26 (Training) Increase emphasis in air carriers training programs on effective use of all available sources of weather information (Class II, Priority Action).	July 21, 1983: FAA has published numerous documents to educate, inform and, in some cases, direct a course of action for dealing with weather information April 2, 1985: FAA's most recent film "Probable Cause" has been distributed to the broadest possible level. Film has gone to air carriers, to accident prevention specialists for public showings, to aviation interest groups and the International Civil Aviation Organization's film library for reproduction and distribution in three different languages.	OAA[a]	- ACOB 7-76-3 stresses the importance of severe weather training - AC 00-24B "Thunderstorms" - ACOB 7-79-1 and AC 00-50A, "Low Level Wind Shear" - ACOB 7-79-3 provides information on airborne weather radar operation - New film on wind shear in preparation May 29, 1984: Film on wind shear and the fact that the FAA plans to continue to provide emphasis on disseminating new information and technology in the area of meteorology to the aviation community are responsive to this recommendation.

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[a] OAA: Open-Acceptable Action

World Airways Accident at Boston Logan Airport, Massachusetts

Date: 1/23/82

Flight Number: 30H

Aircraft Type: DC 10-30

Casualties: 2

Causes: (as determined by NTSB): 1) Pilot landed the airplane without sufficient information as to runway conditions on a slippery, ice covered runway, the condition of which exceeded the airplane stopping capability, 2) FAA regulations did not provide guidance to airport management regarding the measurement of runway slipperiness under adverse conditions 3) FAA regulations did not provide the flight crew and other personnel with the means to correlate contaminated surfaces with airplane stopping distances 4) FAA regulations did not extend authorized minimum runway lengths to reflect reduced braking effectiveness on icy runways 5) Boston Logan Airport failed to exercise maximum efforts to assess and improve the condition of the ice-covered runways to assure continued safety of heavy jet plane operations and 6) Tower controllers failed to transmit available braking information to the pilot of Flight 30H.

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TABLE C-2
NTSB/FAA INTERACTION AFTER WORLD AIRWAYS 30H ACCIDENTS

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-82-154 (Friction Measurement) Require that full certificate airports periodically inspect dry runway surface condition including friction measurements (Class III, Longer Term Action)	September 20, 1983: FAA currently considering several alternative proposals for action involving the use of friction measuring devices for evaluating runway pavement surface conditions. No decision has been taken as yet. An analysis has been iniated to evaluate the cost/benefit relationship that would result from periodic use of friction measuring devices during annual airports certification inspections. Two alternatives include the regulatory imposition of periodic friction measurements on airport operators and the assumption of this this measurement responsibility by the FAA. Study expected to be completed in mid-1984.	OAA[a]	December 14, 1983: NTSB is satisfied with FAA's actions and interested in results of friction measuring devices testing. Open status will be maintained pending FAA's further response following completion of cost/-benefit analysis.
• A-82-156 (PIREPs on Braking Action) Amend ATC procedures so that Air Traffic Controllers require frequent pilot reports on braking action (Class II, Priority Action	November 7, 1983: Proposed amendment of FAA Handbook 7110.65C, Para. 49, PIREP Information, to provide for timely solicitation and dissemination of pilot braking action reports when advisories are in effect and two amendments to the Airman's Information Manual.	CAA[b]	December 14, 1983: NTSB is satisfied with these revisions.

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[a] OAA: Open-Acceptable Action
[b] CAA: Closed-Acceptable Action

TABLE C-2
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued December 23, 1982 • A-82-157 (PIREPs Dissemination) Amend ATC procedures to require that Air Traffic Controllers promptly disseminate PIREPs of "poor to nil" braking action to airport management and all departing and arriving flights (Class II, Priority Action)	November 7, 1983: - FAA Handbook 7210.3F, Para. 430, Letters of Agreement, has been modified to outline responsibilities for dissemination of PIREPs on braking action between tower and airport management. - Provided procedures within FAA Handbook 7110.65C, Para. 980, Departure Information, and 1010, Landing Information for timely relay of braking action PIREPs to departing and arriving aircraft. (Also see A-82-159).	CAA[a]	December 14, 1983: Changes to FAA Handbook 7210.3F and 7110.65C are in complete accord with the intent of recommendation. Closed status is granted.

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[a] CAA: Closed-Acceptable Action

TABLE C-2
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued December 23, 1982 • A-82-159 (Dissemination of Information) Amend ATC procedures to require that the Automatic Terminal Information Service (ATIS) broadcasts:	November 7, 1983: - Procedures included within FAA Handbook 7210.3F, Para. 1230 Automatic Terminal Information Service (ATIS) to clarify the need to update broadcasts based on braking action PIREPs.	CAA[a]	December 14, 1983: NTSB is satisfied with FAA's actions. Changes to FAA Handbook 7210.3F are fully responsive to the objectives of the recommendation. Closed status is granted.
- be updated promptly after braking PIREPs, worse than indicated in current broadcast, are reported	- Also considering procedures for inclusion of statement "braking action advisories are in effect" when necessary (when braking action is changing rapidly).		
- when conditions are conducive to deteriorating braking action, indicate that braking action advisories are in effect (Class II, Priority Action).			

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[a] CAA: Closed-Acceptable Action

TABLE C-2
(Concluded)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-82-160 (Information) Amend the Airman's Information Manual to make pilots aware of ATIS broadcasts indicating that braking action advisories are in effect and require that they provide reports on braking action after landing (Class II, Priority Action)	- Following development of ATC procedures, a corresponding amendment has been made, fully describing pilots' involvement in collection and relay of braking action advisories, to the Airman's Information Manual - Several other paras. are also reviewed (7110.65C, Para. 942 Braking Action) - Bulletin No. 82-2 issued in Dec. '82 was devoted to Winter Operations	CAA[a]	December 14, 1983: Satisfactory amendments to Airman's Information manual. Changes are in complete accord with the intent of the recommendation. Closed status is granted.
• A-82-168 (Research) With NASA, expand current program to evaluate runway friction measuring device which correlate friction measurements with airplane stopping performance to examine the use of airplane systems such as anti-skid brake (Class III, Longer Term Action)	FAA and NASA support research to evaluate friction devices which may correlate friction measurements with airplane performance. However, FAA does not support the concept of a continuous display of braking coefficients (too distracting to the pilot and nonproductive)	OAA[b]	April 1, 1983: FAA and NASA formulating a test program to be accomplished by NASA starting in April 1983. Congress has allocated fiscal year 1983 funding for this program. Class II Longer Term Action is appropriate since technology required to comply with this recommendatopm relies heavily on successful completion of the NASA research effort. May 7, 1984: First phase of testing program has been completed. Analysis of data is being conducted to determine correlation. Analysis will be completed prior to commencing the 2nd half of the program during May 1984. October 26, 1984: NTSB pleased with FAA's action. Pending completion of the second phase of the test and receipt of the final report, A-84-168 is classified as Open-Acceptable Action.

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[a] CAA: Closed-Acceptable Action
[b] OAA: Open-Acceptable Action

Air Florida Accident at Washington, D. C.

Date: 1/13/83

Flight Number: 90

Aircraft Type: Boeing 737-222

Casualties: 78 (74 in plane, 4 on ground)

Major Causes: (as determined by NTSB): Flight crew's failure to: a) use anti-ice during ground takeoff b) to reject takeoff when snow/ice present on airfoil surfaces of aircraft and c) to reject takeoff during early stage when captain's attention was called to anomalous instrument readings

Contributing Factors: (as determined by NTSB): 1) Prolonged ground delay between test deicing and takeoff, 2) Known inherent pitchup characteristics of B-737 when leading edge is contaminated with snow or ice, and 3) Limited experience of flightcrew in jet transport winter operations.

TABLE C-3
NTSB/FAA INTERACTION AFTER AIR FLORIDA 90 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-82-8 (Dissemination of Information) Provide information to flightcrews about the effects of snow/slush contaminated runway on takeoff (Class I, Urgent Action)		CAA[a]	ACOB No. F-82-2
• A-82-12 (Operation) Amend Advisory Circulars 91-13c "Cold Weather Operation of Aircraft" and 91-51,"Airplane Deice and Anti-Ice Systems" to emphasize hazards associated with engine inlet pressure probe icing	Detailed review of AC 91-13C and 91-51 is planned to determine if updating is required.	CAAA[b]	April 1982: NTSB awaiting receipt of new AC 91-13c and 91-51.
Issued August 11, 1982 • A-82-82 (Maintenance) Require revision of B-737 Approved Flight Manual to add "anti-ice" to the normal taxi and take off checklist. Review checklists for all air carrier aircraft	September 28, 1983: FAA completed a review of aircraft checklists. Each Regional Flight Standards Division reported the results to FAA Office of Flight Oeprations. Five regions reported that a total of ten air carriers had taken some form of corrective action to revise their checklist as a result of the recommendation. Additionally, corrective action was recommended to ten Part 91 operators.	CAA[a]	January 6, 1984: NTSB is satisfied with FAA's actions. Completion of comprehensive aircraft checklist review fulfills the objectives of recommendation A-82-82.

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[a] CAA: Closed-Acceptable Action

[b] CAAA: Closed-Acceptable Alternate Action

Air Wisconsin Accident at Valley, Nebraska

Date: 6/12/80

Flight Number: 965

Aircraft Type: Swearingen SA-226

Casualties: 13

Major Cause: (as determined by NTSB): Continued flight into an area of severe thunderstorms; the resultant precipitation induced flameout or loss of power of both engines at an altitude from which recovery could not be made.

Contributing Factors: (as determined by NTSB): Failure of: 1) Flightcrew to utilize all available sources of weather information, 2) ATC system to disseminate critical weather information to air traffic controllers and fight crew, 3) ATC supervisory personnel to accomplish key job functions, and 4) Center Weather Service Unit (CWSU) meteorologists to disseminate critical weather information to the Omaha Radar Approach Control Facility supervisors. Precipitation x-band radar attenuation made it difficult to detect extent and intensity of precipitation on airborne weather radar.

TABLE C-4
NTSB/FAA INTERACTION AFTER AIR WISCONSIN 965 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued September 28, 1977 (Reiterated) • A-77-63 (Weather Information Dissemination) Expedite development of subsystem providing real-time display of precipitation and turbulence. Transmit information either via controller or electronic data link. (Class II, Priority Action)	In August 1975, Air Traffic Service (ATS) initiated an R&D program requesting: - Evaluation of enroute and terminal radars capabilities to detect and display weather - Comparison of ARSR/ASR and NWS radar detection capabilities - Identification of modifications necessary to improve ATC radars - Improvement of ATC radar weather detection without affecting aircraft detection	OAA[a]	August 13, 1984: Update on ongoing programs pertaining to this recommendation. Remoting Color Weather Radar Data to Air Traffic Control Centers (ARTCC) and En Route Flight Advisory Service Locations: To date, approximately 35 percent of the radar system is available for operational use. FAA anticipates that this program will be completed by December 1985. Doppler Weather Radar: The design validation contract award has been accomplished. The prototype radar system contract award should occur this fiscal year with the delivery of a prototype by 1987. Full production should begin in 1987 with delivery scheduled for a 1988 time frame. Color Weather Radar in Terminal Facilities: The Administration had previously evaluated and concluded that color weather radar was not a necessity in the terminal environment. FAA is presently in the process of procuring three weather processors to be installed at various terminal radar facilities for evaluation. No decisions on this subject will be forthcoming until this evaluation has been completed (by July 1985). Meteorologist/Center Weather Service Units: This project has been completed. All centers now have a center weather service unit staffed with National Weather Service meteorologists. Weather Radar Displays for ARTCC Sector Controllers: The evaluation of the prototype system in Cleveland produced negative results. The controllers found it extremely difficult to correlate target and weather information when presented on different scopes. FAA's current plans call for the presentation of weather using the center weather processor. The timeframe associated with this project completion is 1990-1992.

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[a] OAA: Open-Acceptable Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued September 28, 1977 (Reiterated) ● A-77-68 (Weather Information Dissemination) Formulate rules and procedures for timely dissemination by air traffic controllers of all available severe weather information to inbound and outbound flightcrews in the terminal area (Class II, Priority Action)	August 13, 1980: - Center Weather Service Units (CWSU) activated in 13 ARTCC's. 21 CWSU's planned to be operational in 20 ARTCC's by Oct. 1980 - all regions authorized to supplement Handbook 7210-2, Paragraph 820c and 12220b SIGMET dissemination April 7, 1981: FAA currently has all 21 CWSU's in place and operational with procedures established to disseminate weather intelligence to terminal facilities within the ARTCC's area of responsibility Two programs are in progress to provide a more timely method of weather dissemination (touchmatic conference call system and R&D effort for a system providing a hard copy pictorial of pertinent weather).	CAA[a]	- Delivery of system scheduled for March, 1983. - Next Generation Weather Radar (NEXRAD) Operational 1987. - Direct access to a color weather radar display for each ARTCC controller - Touchmatic conference call system to allow communication between facilities requiring weather information (National Airspace Data Exchange Network (NADIN) - R&D effort to develop system that will decrease dissemination time and provide hardcopy of weather - Low Level Wind Shear Alert System installed at 58 airports. Should be installed in 110 airports by the end of 1984. April 17, 1981: NTSB agrees that the introduction of CWSU and LLWAS are responsive to recommendation A-77-68.

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[a] CAA: Closed-Acceptable Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-74-14 (Weather Dissemination Information) With NWS, develop system to relay severe turbulence and tornado warnings expeditiously to inbound and outbound flights.	October 13, 1982: In 1978, with NWS, CWSUs were implemented in all ARTCCs. Terminal ATC personnel are advised of changing weather conditions and provided with updated forecasts. Faster communications network is installed to replace older, slower teletypewriters.	OAA[a]	Hazardous Inflight Weather Advisory Service (HIWAS) - Control Weather Service Unit (CWSU) - Planning a single site operational test of color weather radar display at appropriate air route traffic center control sectors. March 8, 1983: Pending results of review of CWSU activities conducted by FAA and NWS, the recommendation will remain open.
Issued September 28, 1977 (Reiterated) • A-77-65 (Weather Information Dissemination) Transmit SIGMET's more frequently on NAVAIDS so that pilots receive more timely information about hazardous weather.	In May 1977, a revision of priority of duties for FSS specialists was issued to enhance the broadcast program.	CAAA[b]	Hazardous Inflight Weather Advisory Service (HIWAS)
Issued February 14, 1978 (Reiterated) • A-78-1 (Radar) Determine extent of attenuation caused by rain and ice on airborne radomes. Limitations should be known by aviation community (Class II, Priority Action)	April 7, 1981: FAA/NASA initiated research "Assessment of the Existence of Water Layers on Airborne Radomes During Flight in Precipitation" May 20, 1985: NASA's final report "An Investigation of the Existence of a Surface Water Layer on Aircraft Radomes during Simulated Flight in Heavy Precipitation" is transmitted to the FAA. NASA indicates that without further studies, the results of these tests are inconclusive and do not point to any specific action. FAA does not intend to take any further action on this recommendation until more conclusive scientific evidence becomes available on the subject.	OAA[a]	Ongoing research program at Langley/NASA Real-Time testing with F106 Aircraft. June 15, 1981: Pending results of program, recommendation is maintained in an open status.

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[a] OAA: Open-Acceptable Action

[b] CAAA: Closed-Acceptable Alternate Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued April 18, 1974 (Reiterated) ● A-74-13 (Radar) Development of a radar capable of locating severe weather and displaying convective turbulence, used to vector aircraft around severe turbulence	June 10, 1977: System Research and Development Service has designed a modification that will be installed and tested on the New Orleans terminal radar system October 13, 1982: Design and testing of a Doppler weather radar that will detect and display turbulence and wind shear in both the en route and terminal environments is about 50% complete.	OAA[a]	- Next Generation Weather Radar (NEXRAD) - Radar Remoting Weather Display System (RRWDS) March 1983: NTSB will keep status open on this recommendation until the program is completed and new technology is implemented.
Issued January 5, 1981 2 following recommendations made to the NWS: ● A-80-139 (Weather Information Dissemination) Develop specific criteria for CWSU which would govern the issuance of Center Weather advisories to update or supplement convective SIGMET's (Class II, Priority Action)	February 27, 1981: NWS Reply: Present criteria for issuance of weather advisories are satisfactory December 3, 1982: Long explanatory letter	CAA[b]	CWSU program. FAA/NWS Plan to revise CWSU instructions and fully coordinate them with FAA when color radar and communications enhancements become operational

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[a] OAA: Open-Acceptable Action
[b] CAA: Closed-Acceptable Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-80-116 (New Equipment Testing) Schedule testing for NWS weather radar color remote displays at the Cleveland Air Route Traffic Control Center to encompass next season of frequent convective activity (Class II, Priority Action)	July 15, 1983: Testing of NWS weather radar color displays was conducted at Cleveland ARTCC from April through October 1981. Test proved that, with present equipment, the dual display environment at the sector posed a problem to the controller in terms of clutter and distraction. No additional testing is planned.	CAA[a]	
• A-80-117 (Development of New Techniques) Expediate development of appropriate graphic mapping techniques for correlation of NWS weather radar color remote display and ATC's radar display presentation (Class II, Priority Action)	Development of Graphic maps for correlation of weather on color displays and ATC displays was successful. However, information on the color weather monitors presented too much clutter. Weather display monitor was too small to accommodate the required amount of graphics.	CAA[a]	July 5, 1983: An effort to correlate weather and data will continue as part of recommendation A-80-118

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[a] CAA: Closed-Acceptable Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-80-140 (Weather Information Dissemination) Require that all severe weather warnings expected to affect an air traffic control approach facility be transmitted to the facility in most expeditious means available (Class II, Priority)	February 27, 1981: The relay of warnings as suggested would not enhance the accuracy or detail of weather intelligence available to the aviation community December 3, 1982: Long explanatory letter	CAAA[a]	Introduction of high speed communications terminal at the CWSU position will increase the availability of timely weather information. Installation of weather radar at the CWSU position will make real-time weather observations available to FAA air traffic support facilities
Issued November 19, 1980 • A-80-115 (Equipment Modernization) Expedite delivery of NWS weather radar color remote displays to all ATC Centers' Center Weather Service Units (Class I, Urgent Action)	October 15, 1984: Installation of the remote radar weather displays in the Air Route Traffic Control Centers' Center Weather Units has been completed. The digitizers are installed on the FAA's and NWS's radars and are currently being tested. Approximately 35% of the radar system has been completed and is currently in use. Full use of the system is expected by December 1985. June 19, 1985: The Remote Radar Weather Display System (RRWDS) is installed and operational at all of the air route traffic control centers' center weather service units.	OAA[b]	RRWDS network should be in operation towards the middle of 1983 April 22, 1983: Pending completion of the delivery of RRWDS to all CWSU's, status will be maintained open. February 4, 1985: NTSB is pleased with FAA's actions and requests to be kept informed of the progress of this project.

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[a] CAAA: Closed-Acceptable Alternate Action
[b] OAA: Open-Acceptable Action

TABLE C-4
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued November 19, 1980 • A-80-118 (Development of New Techniques) Expedite development of integrated weather radar/air traffic control radar single video display system capable of providing multiple weather echo intensity discrimination without derogation of air traffic control radar intelligence (Class II, Priority Action)	July 15, 1983: FAA concurs with recommendation and effort is currently in progress to integrate air traffic and weather data on a single display	OAA[a]	Projected date for single display is 1988
• A-80-119 (ATCC's Responsibility) Require that ATCC's make maximum use of existing NWS radar sites as inputs to the color remote displays at their facilities (Class II, Priority Action)	Status of this recommendation depends upon implementation of A-80-115. Deliveries of RRWDS are underway	OAA	As of July 11, 1983, 84 radar sites and 27 Center Weather Service Units and En Route Flight Advisory System positions have been equipped with RRWDS. The remainder of the systems should be installed and operating by the end of December.
• A-80-135 (Flow Controller's Responsibility) Require that flow controllers and supervisory personnel assess potential effect of hazardous weather on low-altitude en route traffic and adjust air traffic flow accordingly (Class II, Priority Action)	April 7, 1981: FAA concurs: FAA regions required to place special emphasis on flow-controller meteorologists and supervisors responsibilities concerning the assessment of the effect of hazardous weather on low-altitude en route traffic	CAA[b]	

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[a] OAA: Open-Acceptable Action
[b] CAA: Closed-Acceptable Action

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TABLE C-4
(Concluded)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issue January 5, 1981 • A-80-136 (x-band Radar) Require that the effect of precipitation - attenuation on x-band airborne radar be included in training programs and that manufacturers include attenuation data in operators handbook (Class II, Priority Action).	FAA concurs: Air Carrier Operations Bulletin No. 7-79-3 revised to that effect. Change 21 issued to FAA Order 8430-17 Air Carrier Operations Bulletin, which transmits a revision to Chapter 8, Weather Operations and Instrument Systems, Para. 842, ACOB No. 7-79-3 "Airborne Weather Radar".	CAA[a]	June 8, 1982: NTSB is satisfied with revision.
• A-80-138 (Weather Information Dissemination) Evaluate procedures governing transmission of SIGMET's on NAVAID's to improve timely release. Take corrective measures to ensure they are issued according to procedures (Class II, Priority Action)	FAA concurs: FAA regions required to have Flight Service Station personnel review broadcast and facility directives to ensure that each specialist is aware of the importance of broadcasting hazardous weather advisories	OAA[b]	July 1982: Each region has responded individually. Based on their recommendations, a proposal has been submitted (AAT-364-82-2). This proposal and all comments received are under evaluation. Changes have been completed (December 1982); duty priorities have been revised to ensure timely release of SIGMETs. April 1983: Regional review and evaluation was expected to be completed by June 15, 1981. NTSB requests to be informed of the progress of this recommendation (April 1983). February 8, 1984: FAA's actions are satisfactory; pending complete implementation of the national HIWAS Program, recommendation is maintained in an open status.

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[a] CAA: Closed-Acceptable Action
[b] OAA: Open-Acceptable Action

Southern Airways Accident at New Hope, Georgia

Date: 4/4/77

Flight Number: 242

Aircraft Type: DC-9

Casualties: 71 (62 in plane, 9 on ground)

Major Cause: (as determined by NTSB): Total and unique loss of thrust from both engines while the aircraft was penetrating an area of severe thunderstorms (the loss of thrust was due to the ingestion of massive amounts of water and hail).

Contributing Factors: (as determined by NTSB): 1) Inadequate monitoring of the storm by the airways' flight dispatch personnel, 2) Captain's reliance on airborne weather radar to penetrate thunderstorm areas, and 3) Limitations of FAA's ATC system which precluded the timely dissemination of "real-time" hazardous weather information to the flight crew.

TABLE C-5
NTSB/FAA INTERACTION AFTER SOUTHERN AIRWAYS 242 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued September 27, 28, 1977: • A-77-63 (Weather Information Dissemination) Expedite the development of an aviation weather subsystem for both en route and terminal area capable of providing real-time display of hazardous weather including multiple-intensity classification scheme. Transmit to pilot either via controller or electronic data line (Class II, Priority Followup)	March 17, 1981: In August 1975, Air Traffic Service (ATS) initiated an R&D program requesting - evaluation of en route terminal radars capabilities to detect and display weather - comparison of ARSR/ASR and NWS radar detection capabilities - identification of modifications necessary to improve ATC radars - improvement of ATC radar weather detection without affecting aircraft - Revision of priorities issued by FSS specialists. Broadcast of SIGMETs and AIRMETs given higher priorities.	OAA[a]	August 13, 1984: Update on ongoing programs pertaining to this recommendation. Remoting Color Weather Radar Data to Air Traffic Control Centers (ARTCC) and En Route Flight Advisory Service Locations: To date, approximately 35 percent of the radar system is available for operational use. FAA anticipates that this program will be completed by December 1985. Doppler Weather Radar: The design validation contract award has been accomplished. The prototype radar system contract award should occur this fiscal year with the delivery of a prototype by 1987. Full production should begin in 1987 with delivery scheduled for a 1988 time frame. Color Weather Radar in Terminal Facilities: The Administration had previously evaluated and concluded that color weather radar was not a necessity in the terminal environment. FAA is presently in the process of procuring three weather processors to be installed at various terminal radar facilities for evaluation. No decisions on this subject will be forthcoming until this evaluation has been completed (by July 1985). Meteorologist/Center Weather Service Units: This project has been completed. All centers now have a center weather service unit staffed with National Weather Service meteorologists. Weather Radar Displays for ARTCC Sector Controllers: The evaluation of the prototype system in Cleveland produced negative results. The controllers found it extremely difficult to correlate target and weather information when presented on different scopes. FAA's current plans call for the presentation of weather using the center weather processor. The timeframe associated with this project completion is 1990-1992.

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[a] OAA: Open-Acceptable Action

TABLE C-5
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued September 28, 1977 • A-77-64 (Weather Information) Establish a standard scale of thunderstorm intensity based on NWS, six-level scale. Familiarize pilots and air traffic control personnel with use of this system (Class II, Priority Followup)	ATS has taken necessary steps for implementing this recommendation. DOT/FAA Notice N7110.150 issued on June 12 to acquaint ATC specialist with the descriptive terms used by NWS and authorize their use in the air traffic system. Airman's Information Manual Part 3A contains information on six-level scale.	CAA[a]	Definitions and explanation of the standard six-level scale will also be contained in the Pilot Controller Glossary of the Air Traffic Control Manual effective January 1, 1978.
• A-77-65 (Weather Information) Transmit SIGMET's more frequently on navaids so that pilots can receive more timely information about hazardous weather (Class II, Priority Followup)	- Prior to this accident, FAA had taken action to have both centers and towers make broadcasts on receipt of of all SIGMETs.	CAAA[b]	
	- As FSS modernization proprogram develops, FAA will be able to provide continuous broadcast of advisories.		FSS automation program

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[a] CAA: Closed-Acceptable Action

[b] CAAA: Closed Acceptable Alternate Action

TABLE C-5
(Continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued September 28, 1977 • A-77-66 (Weather Information) Code, according to geographic applicability, Severe Thunderstorm and Tornado Watch Bulletins so that they can be transmitted to appropriate air traffic control facilities which in turn can relay earliest warnings to flightcrews (Class II, Priority Followup)	Project initiated with NWS. A separate aviation severe local storm watch for Service A would be distributed geographically according to states by the FAA Weather Message Switching Center	CAA[a]	
Issued September 28, 1977 • A-77-68 (Weather Information Dissemination) Formulate rules and procedures for the timely dissemination by air traffic controllers of all available severe weather information to inbound and outbound flight crews in the terminal area (Class II, Priority Followup)	Draft plan for analyzing and disseminating severe weather data in terminal areas. Final plan to include a means of delivery to be accomplished without derogating the controller's primary responsibility for preventing mid-air collisions	CAA[a]	April 1981: - Center Weather Service Units (CWSU) - Low Level Wind Shear Alert System (LLWAS) (Installed at 58 airports, expected to be operational at 110 airports by the end of 1984)

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[a] CAA: Closed-Acceptable Action

TABLE C-5
(Concluded)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued February 14, 1978 Langley/NASA. • A-78-1 (Airborne Radar) Initiate research to determine the attenuating effect of precipitation and icing on airborne radomes of both x- and c- band radar and disseminate results to aviation community (Class II, Priority Action)	April 7, 1981: FAA/NASA initiated research "Assessment of the Existence of Water Layers on Airborne Radomes During Flight in Precipitation"	OAA[a].	Ongoing research program at Langley/NASA.

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[a] OAA: Open-Acceptable Action

Allegheny Airlines Accident at Philadelphia, Pennsylvania

Date: 4/23/76

Flight Number: 121

Aircraft Type: DC-9-31

Casualties: 86

Major Cause: (as determined by NTSB): Aircraft's encounter with severe horizontal and vertical wind shears near ground as a result of captain's continued approach into a clearly marginal severe weather condition.

Contributing Factors: (as determined by NTSB): Tower Controller's failure to provide timely below-minimum RVR information.

TABLE C-6
NTSB/FAA INTERACTION AFTER ALLEGHENY AIRLINE 121 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Reiterated two following recommendations, issued September 27, 1977	In August 1975, Air Traffic Service (ATS) initiated an R&D program requesting	OAA[a]	August 13, 1984: Update on ongoing programs pertaining to this recommendation.
• A-77-63 (Weather Information Dissemination) Expedite the development of an aviation weather subsystem for both enroute and terminal area capable of providing real time display of hazardous weather including multiple-intensity classification scheme. Transmit to pilot either via controller or electronic data link. (Class II, Priority Followup)	- evaluation of enroute and terminal radars capabilities to detect and display weather - comparison of ARSR/ASR and NWS radar detection capabilities - identification of modifications necessary to improve ATC radars - improvement of ATC radar weather detection without affecting aircraft detection		Remoting Color Weather Radar Data to Air Traffic Control Centers (ARTCC) and En Route Flight Advisory Service Locations: To date, approximately 35 percent of the radar system is available for operational use. FAA anticipates that this program will be completed by December 1985. Doppler Weather Radar: The design validation contract award has been accomplished. The prototype radar system contract award should occur this fiscal year with the delivery of a prototype by 1987. Full production should begin in 1987 with delivery scheduled for a 1988 time frame. Color Weather Radar in Terminal Facilities: The Administration had previously evaluated and concluded that color weather radar was not a necessity in the terminal environment. FAA is presently in the process of procuring three weather processors to be installed at various terminal radar facilities for evaluation. No decisions on this subject will be forthcoming until this evaluation has been completed (by July 1985). Meteorologist/Center Weather Service Units: This project has been completed. All centers now have a center weather service unit staffed with National Weather Service meteorologists. Weather Radar Displays for ARTCC Sector Controllers: The evaluation of the prototype system in Cleveland produced negative results. The controllers found it extremely difficult to correlate target and weather information when presented on different scopes. FAA's current plans call for the presentation of weather using the center weather processor. The timeframe associated with this project completion is 1990-1992.

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[a] OAA: Open-Acceptable Action

Continental Airlines Accident at Denver, Colorado

Date: 8/7/75

Flight Number: 426

Aircraft Type: Boeing 727

Casualties: 15

Major Cause: (as determined by NTSB): Aircraft's encounter, immediately following take-off, with severe wind shear at an altitude and airspeed which precluded recovery to level flight; the wind shear caused the aircraft to descend at a rate which could not be overcome even though the aircraft was flown at or near its maximum life capability throughout the encounter. Wind shear was generated by the outflow from the thunderstorm over aircraft's departure path.

TABLE C-7
NTSB/FAA INTERACTION AFTER CONTINENTAL AIRLINES 426 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-76-76 (Takeoff Procedures) Evaluate all air carrier takeoff and climb procedures to determine whether different procedures could help flight-crews cope with known or suspected low-altitude wind shear; new procedures - if any - would be incorporated into the air carriers' flight manual (Class II - Priority Followup)	Currently there are no air-borne techniques or procedures which can accommodate the large wind shears encountered by the Continental crew. Best procedure is for the crew to avoid or delay takeoffs under conditions of high wind shear An Advisory Circular (00-50) on Low Level Wind Shear was published on April 8, 1976	CAAA[a]	Low Level Wind Shear Alert System (LLWAS)
Issued September 27, 1977 • A-77-64 (Weather Information) Establish a standard scale of thunderstorm intensity. Familiarize pilots and air traffic control personnel with use of this system (Class II, Priority Followup)	ATS has taken necessary steps for implementing this recommendation. DOT/FAA Notice N7110.510 issued on June 12 to acquaint ATC specialists with the descriptive terms used by the NWS and authorize their use in the air traffic system. Airman's Information Manual Part 3A contains information on six-level scale of thunderstorm intensity	CAA[b]	Definitions and explanation of the standard six-level scale will also be contained in the Pilot-Controller Glossary of the Air Traffic Control Manual and the Flight Service Station Manual effective January 1, 1978.

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[a] CAAA: Closed-Acceptable Alternate Action

[b] CAA: Closed-Acceptable Action

Eastern Airlines Accident at JFK Airport, New York

Date: 6/24/75

Flight Number: 66

Aircraft Type: Boeing 727

Casualties: 113

Major Cause: (as determined by NTSB): Aircraft's encounter with adverse winds associated with a very strong thunderstorm located astride the ILS localizer course, which resulted in a high descent rate into nonfrangible approach light.

Contributing Factors: (as determined by NTSB): Continued use of runway 22L when it should have become evident to both air traffic control personnel and the flight crew that severe weather hazard existed along the approach path.

TABLE C-8
NTSB/FAA INTERACTION AFTER EASTERN AIRLINES 66 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Reiterated 6 following recommendations issued April 18, 1974: • A-74-13 (Improvement of Radar Equipment) Development of ATC radar with better severe weather detection capability.	October 13, 1982: Design and testing of a Doppler Weather Radar that will detect and display turbulence and wind shear in both the en route and terminal environments is about 50% complete.	OAA[a]	- Next Generation Radar (NEXRAD) - Radar Remoting Weather Display System (RRWDS) March 1983: NTSB will maintain status open on this recommendation until the completed and new technology is implemented.
• A-74-14 (Weather Dissemination Information) with NWS, develop system to relay severe turbulence and tornado warnings expeditiously to inbound and outbound flights	Will seek to improve current dissemination practices in conjunction with NWS October 13, 1982: In 1978, with NWS, CWSUs were implemented in all ARTCCs. Terminal ATC personnel are advised of changing weather conditions and provided with updated forecasts. Faster communications network are installed to replace older, slower teletypewriters.	CAA[b]	Hazardous Inflight Weather Advisory Service (HIWAS) Central Weather Service Unit (CWSU March 8, 1983: Pending results of review of CWSU activities conducted by FAA and NWS, the recommendation will be kept in an open status

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[a] OAA: Open-Acceptable Action
[b] CAA: Closed-Acceptable Action

TABLE C-8
(continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued April 18, 1974 • A-74-81 (Training) Issuance of training material and improvements in training programs to stress effect of wind shear	FAA re-emphasized to inspector personnel the importance of proper flight techniques. Will review carrier's training programs When information is available on all aspects of wind shear, FAA will issue an advisory circular	CAA[a]	
Issued April 14, 1974 • A-74-82 (Equipment Development) Expedite the development, testing and operational use of Acoustic Doppler Wind Measuring System	System is being tested at Stapelton airport, Colorado; improvements still needed, specifications will be provided following completion	CAA	Joint Airport Weather Study (JAWS)
Issue April 1, 1976 • A-76-31 (Research) Conduct a research program to define and classify flight hazards implied by thunderstorms and associated winds. Establish operational limitations based upon these criteria (Class II, Priority Followup)	Advanced Notice of Proposed Rule--making (ANPRM) published in May 1979 concerning requirements for airborne windshear systems	CAA	May 1981: - Research programs FAA/National Severe Storm Laboratory, Department of Commerce and NASA to determine the magnitude of windspeed component changes associated with thunderstorms are continuing. - NASA and FAA also evaluating the usefulness of airborne weather radar to identify areas of hazardous wind shear conditions using notifications of existing systems. Ongoing FAA/-NASA programs will provide the capability to measure wind components NEXT Generation Weather Radar (NEXRAD)

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[a] Closed-Acceptable Action

TABLE C-8
(continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued April 1, 1976 • A-76-32 (Equipment Installation Expedite program to develop and install equipment which would facilitate detection and classification of thunderstorms at airports having precision instrument approaches (Class II, Priority Followup)	Ongoing programs	CAA[a]	April 1981: - Joint Airport Weather Study (JAWS) - Next Generation Weather Radar (NEXRAD) - Flight Service Automation System (FSAS Low-Level Wind Shear Alert System - LLWAS)
• A-76-33 (Equipment Installation) Install equipment capable of detecting variations of windspeed along projected takeoff and approach flightpaths (Class II, Priority Followup)	May 1, 1981 Ongoing programs involving development of sensors to detect variations in wind components (acoustic radar, Doppler radar, pulsed laser Doppler, FM/CW	CAA[a]	- Low Level Wind Shear Alert System (LLWAS) (59 systems presently in operation - 51 additional systems will be implemented from 1983-1985) - NEXRAD FAA/FSS Automation Program
• A-76-35 (Equipment Installation) Install equipment for measuring speed and direction of surface wind in vicinity of all runway ends and install lighted windsocks near to the side of runway at airports serving air carrier operations (Class I, Urgent Followup)	Ongoing program, installation underway	CAA	Installation of Low Level Wind Shear Alert System (LLWAS) anemometer array around airports to provide local controllers and pilots with indications of shifting ground-level winds

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[a] CAA: Closed Acceptable Action

TABLE C-8
(continued)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued April 1, 1976 • A-76-36 (Weather Information Dissemination) Develop and institute procedures to provide timely information on thunderstorm activity near departure or flight paths to pilots and tower controllers (Class I, Urgent Followup)	May 1, 1981: Several ongoing programs address this recommendation	OAA[a]	- Air Route Traffic Control Centers (ARTCC's) with commissioned Center Weather Service Units (CWSU) - En Route Flight Advisory Service (EFAS) - National Airspace Data Interchange Network (NADIN) - Color Weather Radar System
• A-76-37 (ATC Procedures) Revise ATC procedures to specify that location and severity of thunderstorms be used as one of the criteria for selecting active runways (Class I, Urgent Followup)	Current ATC procedures, which require aircraft to be informed of hazardous weather conditions, provide the best current means of providing pilots with the information they need to determine the most appropriate action. Decisions of this nature must remain with the pilot. ATC has not present effective means of assessing the current severity of thunderstorm activity	CAA[b]	January 1980: - Low Level Wind Shear Alert System (20 operational, 58 by 1983) - ATC Procedures Handbook 7110.65A (now makes provision for use of LLWAS equipment) - Facility Operations Handbook 7210.3E, improved collection and dissemination of SIGMET's AND PIREPs also includes specific assignment of responsibility for "selecting active runways". August 21, 1981: NTSB reemphasizes that thunderstorms information provided to approach controllers and tower controllers should be *timely*. NTSB wishes to be informed of FAA's progress in this area.

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[a] OAA: Open-Acceptable Action
[b] CAA: Closed-Acceptable Action

TABLE C-8
(concluded)

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
Issued April 1, 1976 ● A-76-39 (Pilots'Training) Modify initial and recurrent pilots training programs and tests to ensure pilots have thorough knowledge of low--level wind conditions associated with thunderstorms and their effect on airplane's performance (Class II, Priority Followup)	Air Carrier Operations bulletin No. 75-8 "Low Level Wind Shear" was issued on December 30, 1975 and requires principal operations inspectors to comply with this recommendation	CAA[a]	
● A-76-40 (Research) Expedite program to develop typical models of environmental winds associated with thunderstorms which can be used for demonstration purposes in pilot training simulators (Class II, Long Term Followup)	FAA, along with NASA and NoAA has developed models of environmental winds associated with mature thunderstorms. These models are now being utilized in pilot simulator training program	CAA	

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[a] CAA: Closed-Acceptable Action

Ozark Airlines Accident at St. Louis, Missouri

Data: 7/23/73

Flight Number: 809

Aircraft Type: FH-227B

Casualties: 38

Major Cause: (as determined by NTSB): Aircraft's encounter with downdraft following the captain's decision to initiate and continue an instrument approach into a thunderstorm.

Contributing Factors: (as determined by NTSB): Captain's decision was influenced by: 1) lack of timely issuance of a severe weather warning by NWS, and 2) improper assessment of weather conditions in the terminal area by the flight crew and flight dispatcher.

TABLE C-9
NTSB/FAA INTERACTION AFTER OZARK AIRLINES 809 ACCIDENT

NTSB Recommendations	FAA Reply	Status	FAA Program/Status of Action
• A-74-13 (Improvement of Radar Equipment) Development of ATC radar with better severe weather detection capability	October 13, 1982: Design and testing of a Doppler Weather Radar that will detect and display turbulence and wind shear in both the en route and terminal environments is about 50% complete	OAA[a]	- Next Generation Radar (NEXRAD) - Radar Remoting Weather Display System (RRWDS) March 1983: NTSB will maintain status open on this recommendation until the program is completed and new technology is implemented
• A-74-14 (Weather Dissemination Information) With NWS, develop system to relay severe turbulence and tornado warnings expeditiously in inbound and outbound flights.	Will seek to improve current dissemination practices in conjunction with NWS. October 13, 1982: In 1978, with NWS, CWSUs were implemented in all ARTCCs. Terminal ATC personnel are advised of changing weather conditions and provided with updated forecasts. Faster communications network are installed to replace older, slower teletypewriters.	OAA	Hazardous Inflight Weather Advisory Service (HIWAS) Central Weather Service Unit (CWSU) March 8, 1983: Pending results of review of CWSU activities conducted by FAA and NWS, the recommendation will be kept in an open status

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[a] OAA: Open-Acceptable Action

APPENDIX D

ACRONYMS

ACARS - ARINC Communications Addressing and Reporting System
ACCC - Area Control Computer Complex
ACF - Air Control Facility
AERA - Automated En Route Air Traffic Control
AFCU - Area Forecast Coordination Unit
AFGL - Air Force Geophysics Laboratory
AFGWC - Air Force Global Weather Central
AFOS - Automation of Field Operations and Services
AFSS - Automated Flight Service Station
AFTN - Aeronautical Fixed Telecommunications Network
AIM - Airman's Information Manual
AIREP - Aircraft Meteorological Report
AIRMET - Airman's Meteorological Information
AGL - Above Ground Level
ALPA - Airline Pilots Association
ALWOS - Automated Low-Cost Weather Observation System
AMDAR - Aircraft Meteorological Data Relay
AOPA - Aircraft Owners and Pilots Association
ARF - Aviation Route Forecast
ARINC - Aeronautical Radio Incorporated
ARSR - Air Route Surveillance Radar
ARTCC - Air Route Traffic Control Center
ARTS - Automated Radar Terminal System
ASDAR - Aircraft to Satellite Data Relay
ASOS - Automated Surface Observing System
ASR - Airport Surveillance Radar
ATA - Air Transport Association of America
ATC - Air Traffic Control
ATCRBS - Air Traffic Control Radar Beacon System
ATCT - Airport Traffic Control Tower
ATIS - Automatic Terminal Information Service
ATS - Air Traffic Service
AWDS - Automated Weather Distribution System
AWFTF - Aviation Weather Forecast Task Force
AWIPS-90- Advanced Weather Interactive Processing System of 1990's
AWN - Automated Weather Network
AWOS - Automated Weather Observing System
AWP - Aviation Weather Processor
AZRAN - Radar Azimuth and Range

BRITE - Bright Radar Indicator Tower Equipment

CAT - Clear Air Turbulence

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Cb - Cumulonimbus Cloud
CFCF - Central Flow Control Facility
CFWSU - Central Flow Weather Service Unit
CNS - Consolidated NOTAM System
COMEDS - CONUS Meteorological Data System
CONUS - Continental United States
CRD - Computer Readout Device
CRREL - Cold Regions Research and Engineering Laboratory
CSIS - Centralized Storm Information System
CSO - Community Service Office
CWA - Center Weather Advisory
CWP - Central Weather Processor
CWSU - Center Weather Service Unit

DARC - Direct Access Radar Channel
DIFAX - Digital Facsimile Circuit
DMSP - Defense Meteorological Satellite Program
DoC - Department of Commerce
DOI - Department of Interior
DOT - Department of Transportation
DUAT - Direct User Access Terminal
DOD - Department of Defense

EFAS - En Route Flight Advisory Service

FAA - Federal Aviation Administration
FBO - Fixed Base Operator
FD - Wind and Temperature Aloft Forecast
FL - Flight Level
FSAS - Flight Service Automation System
FSDPS - Flight Service Data Processing System
FSS - Flight Service Station
FT - Terminal Forecast

GAMA - General Aviation Manufacturers Association
GAR - General Aviation Reservation
GIM - General Information Message
GOES - Geostationary Operational Environmental Satellite

HAI - Helicopter Association International
HF - High Frequency
HIWAS - Hazardous In-flight Weather Advisory Service

ICMSSR - Interdepartmental Committee for Meteorological Services and Supporting Research
IFR - Instrument Flight Rules
IPADS - Interactive Processing and Display System
IVRS - Interim Voice Response System

JAWS - Joint Airport Weather Studies
JAWOP - Joint Automated Weather Observation Program
JSPO - Joint System Program Office

LAWRS - Limited Aviation Weather Reporting Station
LF - Low Frequency Band
LFM - Limited Fine Mesh
Lidar - Light Detecting and Ranging
LLWAS - Low Level Wind Shear Alert System
LPATS - Lightning, Positioning and Tracking System

MERIT - Minimum Energy Route Interactive Techniques
MIS - Meteorological Impact Statement
MOAT - Meteorological Optional Auxiliary Terminal
NADIN - National Airspace Data Interchange Network
NAFAX - National Facsimile Circuit
NAIPC - National Aviation Icing Program Council
NAR - National Airspace Review
NAS - National Airspace System
NASA - National Aeronautics and Space Administration
NAWAU - National Aviation Weather Advisory Unit
NBAA - National Business Aircraft Association
NEDS - Naval Environmental Display Station
NESDIS - National Environmental Satellite Data and Information Service
NESS - National Earth Satellite Service
NHC - National Hurricane Center
NEXRAD - Next Generation Weather Radar
NICS - National Interfacility Communications System
NMC - National Meteorological Center
NOAA - National Oceanic and Atmospheric Administration
NOGAPS - Navy Operational Global Atmospheric Prediction System
NOTAM - Notice to Airmen
NSF - National Science Foundation
NSSL - National Severe Storms Laboratory
NSSFC - National Severe Storms Forecast Center
NTSB - National Transportation Safety Board
NWS - National Weather Service

OFCM - Office of Federal Coordinator for Meteorological Services
OMB - Office of Management and Budget
OTS - Organized Track System

PATWAS - Pilots Automatic Telephone Weather Answering Service
PIREP - Pilot Report
PREMAP - Precipitation and Soil Moisture Mapping
PROFS - Prototype Regional Observing and Forecasting Service

RAREP - Radar Report
REAMOS - Remote Automated Meteorological Observing System
RF - Radio Frequency
RML - Radar Microwave Link
RRWDS - Radar Remote Weather Display System
RVR - Runway Visual Range
RVV - Runway Visibility Value

SA - Surface Weather Observations
SAWRS - Supplementary Aviation Weather Reporting Station
SCAN - Switch Circuit Automatic Network
SHDS - Satellite Data Handling System
SIGMET - Significant Meteorological Information
SMOOS - Shipboard Meteorological and Oceanographic Observing System
STORM - Stormscale Operational and Research Meteorology

TCCC - Terminal Control Computer Complex
TDWR - Terminal Doppler Weather Radar
TOMS - Total Ozone Mapping Spectrometer
TRACON - Terminal Radar Approach Control
TWEB - Transcribed Weather En Route Broadcast

UHF - Ultra High Frequency
USAF - United States Air Force
USN - United States Navy

VAS - Visible Atmospheric Sounder
VFR - Visual Flight Rules
VHF - Very High Frequency
VISSR - Visible Infra-red Spin Scan Radiometer
VOR - Very High Frequency Omnidirectional Range
VRS - Voice Response System
VSCS - Voice Switching and Control System

WBRR - Weather Bureau Remote Radar
WCP - Weather Communications Processor
WFMU - Weather and Fixed Map Unit
WFO - Warning and Forecast Office
WG/AWIS - Working Group on Automated Weather Information Systems
WGP - Grid Wind and Temperature Data
WINDSAT - Wind Satellite
WMO - World Meteorological Organization
WMSC - Weather Message Switching Center
WSFO - Weather Service Forecast Office
WSO - Weather Service Office
WSR - Weather Search Radar

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